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Water-Based Air Logistics

FLYING-BOATS—a species of marine aircraft that once flourished in these islands—have been built over the years for transport, patrol, reconnaissance, bombing, mine-laying, and even as fighters and tank-landing craft. In recent times they have been adapted as flight-refuelling tankers; and one of the very latest (for they are far from moribund in other lands) is a jet "commuting ship."

Of all their possible applications, that of military airlift, either for limited or global warfare, is potentially the most rewarding. The case is presented by Mr. Guy Mallery, project engineer of the Martin company, whose four-jet 600-m.p.h. SeaMaster minelayer is in limited production for the U.S. Navy. Current strategic and tactical doctrines, Mr. Mallery points out, demand unprecedented speed of reaction to enemy attack. Strategic reserves must be transferred to combat theatres in a matter of hours rather than weeks, and new types of weapons and weapons carriers, together with helicopters, must be rushed to the atomic battlefield.

In this knowledge the ground forces have been at pains to reduce the size and weight of their equipment; but Mr. Mallery argues that the emphasis should be on satisfying the needs of those forces for their special fighting tools and not on compromising the tools so that they can fit into the limited dimensions of today's transport aircraft. His contention is a difficult one to refute; and his advocacy of the flying-boat—having in mind the possibilities of designing it to any size, regardless of the availability or suitability of terminal land facilities—has a supporter in the U.S. Army's Chief of Transportation, who has delivered himself of a sentiment not unheard in these islands a few years ago. "We are interested in water-borne aircraft," he said, "because we operate in areas where no runways or hangars are available. Water-borne aircraft land where the Lord has provided for us . . ."

Encouraged by the joint blessings of Providence and the U.S. Army, the Martin engineer comes forward with an offer of an eight- or ten-jet leviathan—the SeaMistress—displacing something between 200 and 300 tons, carrying 400 troops, or three light tanks, or a fully equipped infantry company with vehicles and three days' rations. Refuelling would be possible in flight or at sea.

Getting at the Trouble

These impressive capabilities must, of course, be related to facilities existing in possible trouble-spots—Turkey, for instance, where the destruction of only three airfields could preclude the fulfilment of strategic commitments by land-based machines, but where some two thousand miles of coastal waters and more than a score of usable interior lakes would be available to marine aircraft.

In terms of time and movement it has been calculated that if trouble developed in the Middle East a period of 45 days would be required for the sea transport of three fully equipped army divisions from the United States to the scene of action. In the same period more than 900 land-based aircraft—provided by the Military Air Transport Service and the commercial airlines—could lift only two divisions—and those without their heavier equipment. But in a mere 15 days or so, about a hundred fast, heavy flying-boats could, it is suggested, move the entire three divisions plus all their equipment.

As for cost, this would clearly have to be borne jointly by all three Services; and in terms of economics an actual British example is cited by Mr. Mallery. "It is interesting to note," he says, "that in 1953, a Select Committee in the British Parliament, set up to study costs of air transport . . . reported that, in the case of troop movements to Egypt, the cost on military troopships amounted to $85.50 per soldier as against only $62.50 per soldier on chartered aircraft."

We hear from our friends at Martin that Mr. Mallery and several of his colleagues are presenting their case in a continuing series of briefings to military and industrial leaders, Government departments and Congressional representatives; and we believe that they would be rendering a service to Britain if they were to present the full text of their thesis to the Ministry of Defence Amphibious Warfare Department, Whitehall, London (copy to the Treasury at the same address).

FROM ALL QUARTERS

Shorts' Royal Visitor

A DISTINGUISHED visitor to the Belfast works of Short Brothers and Harland, Ltd., last Friday was H.R.H. the Duke of Gloucester. In the course of a two-hour tour in the company of the chairman, Sir Matthew Slattery, the Duke saw the SC.1 being made ready for its tethered-hovering trials; he also inspected the Britannia production line.

Silent Satellite

RADIO transmissions from the Russian Earth satellite were reported by the Mullard radio-astronomical laboratory, Cambridge, to have ceased last Friday, October 25, and the Soviet news agency Tass confirmed during the weekend that the batteries carried by the satellite had become exhausted. They had provided power for continuous transmissions for a period of three weeks from the initial launching.

At the request of the Royal Observatory and the Russian Astronomical Council, the Jodrell Bank radio-telescope was used to locate and track the satellite's final-stage rocket case on October 26. The object was picked up at a range of more than 1,000 miles and, according to Prof. A. C. B. Lovell, was 80 minutes ahead of the satellite. The observations indicated that the orbit of the rocket was descending more slowly than had been expected.

A shaggy dog named Kudryavka appeared before the microphones of Moscow Radio on October 27. It was said to have made several rocket flights to high altitudes, and to belong to a team of dogs which had been conditioned in preparation for the launching of the first animal-carrying satellite.

U.S. Missile Progress

SPURRED on by the presence of Sputnik—the Soviet satellite described in our issue of October 11—several American missile programmes have begun to yield successful results. That most closely associated with the Russian satellite is Project Vanguard which is, in fact, the American counterpart. On October 23 a complete Vanguard vehicle was successfully launched and, even though only the first-stage engine was fitted, an altitude of 109 miles and a speed of 4,250 m.p.h. (in excess of the design figures) were reached.

Another research programme which has at last yielded success is Project Farside, in which small instrument-carrying rockets are being launched from balloons some 20 miles above Eniwetok atoll. After several failures, two Farside rockets were successfully fired on October 23. One reached an altitude of approximately 1,000 miles and the other is believed to have reached between 1,000 and 4,000 miles, although failure of the telemetering as the rocket passed through the balloon cut off all transmission of information. (These rockets, of course, are not established in an orbit and merely fall back to earth.)

Progress with guided weapons has included Thor, Jupiter and Bomarc. A Thor IRBM was fired from Patrick A.F.B. on October 24 and it achieved an almost perfect mission of some 1,500 miles, landing "in the pre-selected impact area." The U.S.A.F. claimed that it was the third completely successful firing in eight attempts. Its competitor, the Army Jupiter, has had fewer failures and achieved another perfect mission from Patrick A.F.B. on the night of October 22. The big U.S.A.F. Bomarc anti-aircraft missile achieved a singular success on October 23. A test round was fired against a B-17 more than 100 miles out in the Atlantic and, even though no warhead was fitted, the Bomarc dived on its target from more than 60,000ft and actually hit and destroyed it.

PanAm and Their 707-120s

ACCORDING to the *Seattle Times*, Pan American World Airways may sell or lease their Boeing 707-120s and order 717s or Convair 880s instead. PanAm are due to receive their first 707-120s in December 1958, but these aircraft will not be suitable for regular transatlantic service (although they may be used to inaugurate token services). More probably they will be employed on the airline's routes to South America, for which medium jets would be more suitable. The same source reports that the company will use their 21 DC-8s for transatlantic services and their 17 707-320s for transpacific services.

Two years ago, when PanAm placed their historic order for Boeing 707s and Douglas DC-8s, Boeing stated that the first 707-120 would roll off the Seattle assembly line in October 1957. This event duly took place on October 27.

WINNER of a U.S. Navy Bureau of Aeronautics design competition for a utility helicopter is the Kaman HU2K, powered with a General Electric T38 turbine, and shown as a mock-up.

Airships on TV

ON B.B.C. television last Friday, in the series *First Hand*, viewers were treated to a feature on airships. The programme was about evenly divided between some remarkable film extracts (onward from the time of Santos-Dumont's Eiffel Tower flight of 1901) and studio interviews with six men who had practical experience with dirigibles; and it would be difficult to say which of the two treatments was the more absorbing.

The six old hands interviewed by Peter West were Cdr. F. M. Simon, R.N., who navigated the Wellman airship which attempted an Atlantic crossing in 1910, to meet gallant failure, ending in rescue by a ship, after 1,000 miles in 72 hours; W/C. J. N. Fletcher, with some entertaining reminiscences of the early Army airships flown by No. 1 Sqn., R.F.C.; Maj. J. C. Struthers, who was responsible for 16 of the 27 attacks on U-boats made by the British Naval airships that flew 9,000 patrols during World War 1; Mr. F. P. Browdie, an engineer in R.34 during her double Atlantic crossing in 1919, with recollections of cooking the crews' meals in boilers on the exhaust-pipes of the Sunbeam Maori engines; W/C. R. S. Booth, captain of the R.33 and the R.100 on several historic long-distance flights; and Lord Ventry (whose Airship Club built the

RESEARCH AND RECONNAISSANCE: Recent visitors to Shorts at Belfast (below, left) were W/C. Larson (centre) and S/L. Hubbard, both from R.A.E. Bedford. They are seen with Tom Brooke-Smith (left), Shorts' chief test pilot, on the platform of the special gantry in which the SC.1 jet-lift research aircraft is soon to undergo initial hovering trials. The second picture shows Avro test pilot Johnny Baker taking leave of Major Eden and Captain Van der Walt of the S.A.A.F., who were about to fly the fourth and fifth Shackleton M.R.3 aircraft from Woodford to South Africa.

TOUGH BABY: The Fairey Ultra-Light helicopter has recently undergone trials to determine the practicability of operating reconnaissance helicopters from small ships. The tiny machine is seen on the platform from which it operated from H.M.S. "Grenville" in exceptionally rough Channel weather. More than 70 landings and take-offs were accomplished in winds measured on the bridge at 62 kt, with the deck pitching 10-12ft and rolling up to 14 deg in each direction.

little non-rigid *Bournemouth* only six years ago), perennial protagonist of the airship as a passenger vehicle.

A little more time, we thought, might have been granted to the achievements of the modern Goodyear non-rigids of the U.S. Navy.

At the invitation of the producer, Paul Johnstone, and his assistant Nancy Thomas, we were able to watch the immediate pre-broadcast rehearsal of this programme: a fascinating experience which, though in some ways reminiscent of a visit to the air traffic control centre at L.A.P., can claim no space here.

The next evening, on "steam" radio, the B.B.C. put out another first-rate effort—a whole hour of recordings by Trevor Hill on a Britannia flight from Hong Kong to London.

Hiller-Bristol 192?

ALTHOUGH confirmation is not forthcoming from Bristol, it is reported in the U.S.A. that Hiller Helicopters Inc., of Palo Alto, California, have been discussing with Bristol Aircraft, Ltd., the possibility of their production of the Bristol 192 under licence. It is also stated that the Napier Gazelle, two of which power the 192, may possibly be licence-produced by the Curtiss-Wright Corporation.

For Young Enthusiasts

COVERING every aspect of flying at present and in future, the *Boys' Book of Flight** provides a ready answer for anxious fathers or uncles or godparents puzzling over Christmas gifts, and deserves a place of honour on every air-minded boy's bookshelf. What boy, in fact, is not air-minded in these days? Enthusiasm for aircraft has superseded that felt by the pre-war young generation for racing-cars, and train-spotters have now been largely out-moded by aircraft spotters: London Airport is to today's youngsters what motor-racing at Brooklands was to their fathers, and No. 111 Sqn. has almost supplanted the Cornish Riviera Express in juvenile affections.

For this large and ever-ready audience David Le Roi has written (in association with the editorial staff of *Flight*) a book which should educate its readers in every aspect of aviation and answer practically all their questions, ranging as it does from the heat and sound barriers and space satellites to airports and airways and flight refuelling. The text is abundantly illustrated with both ground and air-to-air photographs and with general arrangement drawings; while several sectional drawings show some famous civil aircraft and two outstanding British engines in detail.

In a foreword, Lt-Cdr. Peter Twiss—holder of the world's official speed record of 1,132 m.p.h.—says that the *Boys' Book of Flight*, "while presenting some of the sensationalism and excitement of flying," is also factual and technically accurate. "It makes clear," he says, "a lot of the apparently mysterious things going on in aviation today: what is the sound barrier; how does a jet engine work; what is a Coleopter; how does a guided missile find its target; how does a helicopter hover; what is a Rotodyne?"

Peter Twiss is one of today's heroes, as were Captain Scott and Sir Henry Segrave of our yesterdays, and his recommendation is the highest that could be given for a book of this kind. Interest, authority, readability, attractiveness are its outstanding qualities; and it thus forms an indispensable addition to aeronautical literature for the younger generation.

* *Boys' Book of Flight, by David Le Roi, in association with the Staff of "Flight." Foreword by Peter Twiss. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Illustrated. Price 12s. 6d.*

IN BRIEF

A MEMORIAL service for the late Robert V. Perfect—sales and publicity director of Saunders-Roe, Ltd., who died in Sydney on August 4—will be held at Christ Church, Down Street, London, W.1, on Thursday, November 14 at 12 noon.

* * *

The Royal Aero Club's next film show at Londonderry House, Park Lane, London, W.1, will take place at 6.15 p.m. on Thursday, November 7, and will feature the film *Twelve o'Clock High*. The performance is open to members, associate members and guests of the club.

* * *

Mr. W. J. Miller, general manager of the Scottish Group of Rolls-Royce, Ltd., said in Glasgow recently that the value of aero-engines exported from Scotland is now approaching £10m a year. He was opening an aero-engine exhibition sponsored jointly by the company and Glasgow Corporation, at which one of the earliest Rolls-Royce engines (the Eagle) and one of their latest (the Conway by-pass) were among those on view.

* * *

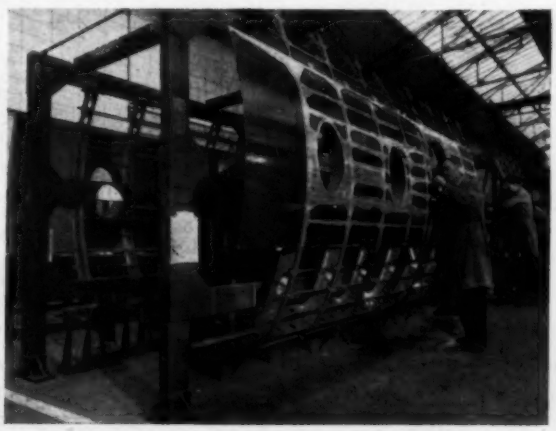
Nearly 50 students and members of staff of the Empire Test Pilots' School, under their commandant, G/C. R. E. Burns, last week visited the Handley Page aerodrome and works at Radlett. They inspected the company's test-house and a laminar-flow research aircraft and heard talks by Mr. G. H. Lee (deputy chief designer), S/L. H. G. Hazelden (chief test pilot) and Dr. G. V. Lachmann, director of the research department.

* * *

At Icknield Secondary Modern Boys' School speech day, Mr. C. L. Cowdrey, manager of the flight development establishment of D. Napier and Son, Ltd., said he doubted whether the present method of training apprentices developed "characteristics which make for leadership" and added that he would like to see a return to some of the old methods. In Mr. Cowdrey's early days the apprentice "had to fight his own way from department to department"; there was no education officer to steer the budding engineer through the works and make peace with the foreman, and at the end of his training an apprentice was bluntly told it was time he went elsewhere to obtain wider experience. "In my opinion," said Mr. Cowdrey, "industry today tends to spoon-feed its youths and to go on nursing them after the completion of their apprenticeship."

* * *

Brig.-Gen. John M. Sterling, U.S.A.F. (ret.), has been appointed assistant to Alden R. Crawford, Republic Aviation's vice-president for European operations. Gen. Sterling, who is 53 and has 5,000 hours' flying experience, will work from the company's Paris office and assist Mr. Crawford in supervising Republic's sub-contracting and field service activities in NATO countries.



COMMERCIAL COACHWORK: The fuselage of an AW.650 Freighter-coach takes shape on the jigs at Baginton. Two of these machines will be used for structural tests, and it is hoped that British and American C. of A.s will be obtained with a minimum delay after the first flight in October 1958. A first batch of ten is being built.

Beirut's five modern airport buildings must soon be extended or modified to cope with the expansion of Lebanon traffic. There are now a thousand aircraft movements a month at this busy terminal.

Middle East Airlines Spreads its Wings

Under the Cedar Tree

By A. T. PUGH

AT the eastern end of the Mediterranean, where the mainland of Turkey overhangs the island of Cyprus and branches of the Egyptian Nile thrust their way through the Delta into the sea, lies the flank of coastline of the Biblical lands. In the cockpit of the countries accredited with the genesis of civilization (Damascus is reputed to be the oldest town in the world) tiny, prosperous Lebanon boasts a political stability not always enjoyed by its Syrian, Israeli and Turkish neighbours.

Long ago, the traditional economy of the district was the export from the ancient ports of Tyre and Sidon of cedar trees gathered from the slopes and mountains around Mount Lebanon; and the civilization and culture of the country were expressed by the temples of the Phœnician city of Baalbeck, in the plain between mountain ranges that was the granary of the Roman armies.

The outward signs of a modern economy, which is largely based on banking and commerce, are a capital that is as cosmopolitan as any in the world and a fine airport serving the needs of the 34 airlines which use Beirut. Viscount services, with stops at Rome, Zurich and Athens, have put the Lebanon a comfortable 12 hours from London, as I recently had the opportunity of discovering for myself on a sample Middle East Airlines flight between L.A.P. and Beirut International Airport.

A short stop at Athens—in the dark little more than a collection of lights and one more international airport selling national souvenirs in the transit lounge—gave me an insight into the determination of Mr. Onassis to make Olympic Airways a first-class airline; and all the indications, from the turn-out of the DC-3s and 6s to the size and smartness of the ground installations, are that Olympic will be ready for their DC-8s when these are delivered in 1960.

From Athens to Beirut is 1,146 miles, and after 2 hr 30 min we arrived over the lights of the town stretching far up into the hills. Mediterranean lights have, I think, a distinctive appearance quite unlike either the lights of British towns, which are white or sodium-yellow and sometimes softened by mist, or the harsh intensity of American coloured lighting. They are smaller and yellower, with multi-coloured neon signs around the hotel and night club areas and unexplained coloured pinpoints in the hills.

Surprisingly enough, since Beirut International Airport (the locals copy our own abbreviating processes to refer to it as B.I.A.) has only been unserviceable through bad weather for three hours in the last seven years, we were stood-off for ten minutes; but with 34 airlines using the airport and a thousand movements a month, traffic intensity can become very considerable. Because of the facilities and communications available at Beirut, and the stability of conditions in the area (rather like Switzerland, three-language Lebanon is valuable to itself and its neighbours as a non-partisan State), more and more airlines are using the airport. Both Beirut and Damascus give flight information on request, although neither is actually a Flight Information Centre (the nearest one, which is to be opened very shortly, is at Nicosia in Cyprus). B.I.A.'s fair weather (there have *never* been any diversions and the cloudbase has *never* been less than 500ft), gives it a claim to become the F.I.C. for this area and the matter will be among those discussed at the I.C.A.O. EuMed meeting in Paris next year.

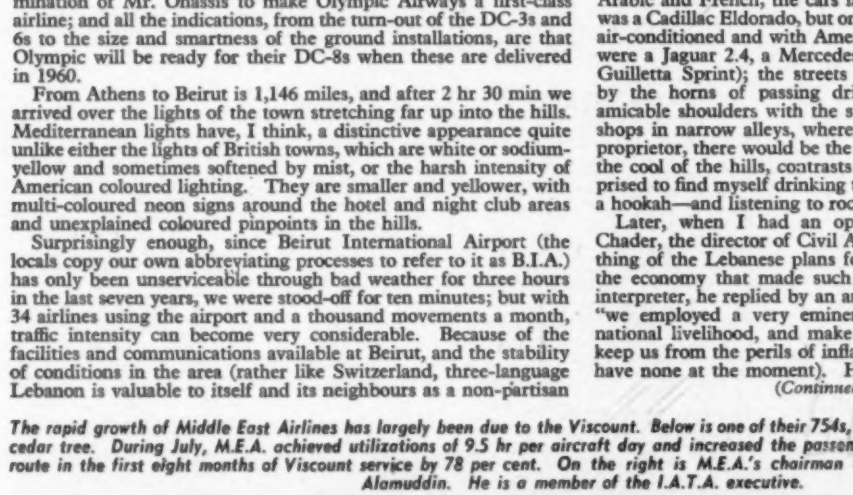
Facilities and equipment, as the airport personnel were very ready to show, are rapidly being expanded; V.O.R. is being installed and radar will be added later. By summer next year the teletype service should include a direct link with London. In the matter of runways B.I.A. is adequately equipped for present needs, and plans are already well advanced for extension of the north-south runway to 9,000ft (and eventually 19,168ft) and the NE/SW runway to 10,500ft. A 1956 American mission to the Lebanon which proposed the method of runway extensions estimated that 9,400ft would be sufficient for a fully-loaded DC-8 at standard temperature, and that the 10,500ft available on the NE/SW runway would be sufficient at maximum listed temperature—a forecast which seems optimistic when Beirut's maximum temperatures of about ISA +27 deg C are considered. (These maxima are, however, of short duration.)

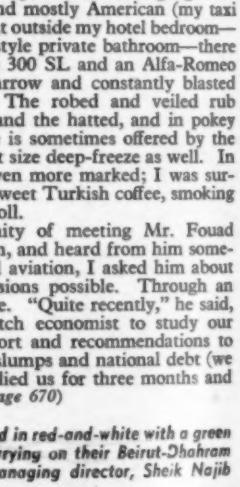
Any first-time visitor to Beirut must inevitably be surprised at the contrasts the town presents. The predominant languages are Arabic and French, the cars large and mostly American (my taxi was a Cadillac Eldorado, but one night outside my hotel bedroom—air-conditioned and with American-style private bathroom—there were a Jaguar 2.4, a Mercedes-Benz 300 SL and an Alfa-Romeo Guilletta Sprint); the streets are narrow and constantly blasted by the horns of passing drivers. The robed and veiled rub amicable shoulders with the suited and the hatted, and in pokey shops in narrow alleys, where coffee is sometimes offered by the proprietor, there would be the largest size deep-freeze as well. In the cool of the hills, contrasts are even more marked; I was surprised to find myself drinking thick sweet Turkish coffee, smoking a hookah—and listening to rock 'n' roll.

Later, when I had an opportunity of meeting Mr. Fouad Chader, the director of Civil Aviation, and heard from him something of the Lebanese plans for civil aviation, I asked him about the economy that made such extensions possible. Through an interpreter, he replied by an anecdote. "Quite recently," he said, "we employed a very eminent Dutch economist to study our national livelihood, and make a report and recommendations to keep us from the perils of inflation, slumps and national debt (we have none at the moment). He studied us for three months and

(*Continued on page 670*)

The rapid growth of Middle East Airlines has largely been due to the Viscount. Below is one of their 754s, finished in red-and-white with a green cedar tree. During July, M.E.A. achieved utilizations of 9.5 hr per aircraft day and increased the passenger-carrying on their Beirut-Dhahram route in the first eight months of Viscount service by 78 per cent. On the right is M.E.A.'s chairman and managing director, Sheik Najib Alamuddin. He is a member of the I.A.T.A. executive.





Marking the end of a memorable visit to Canada and the United States, the B.O.A.C. DC-7C which flew the Queen and Prince Philip back to England on October 22 taxies in at London Airport. Capt. Gordon Store was in command, as on the outward flight. The same aircraft flew the Prime Minister, Mr. Harold Macmillan, to Washington on the following day for talks with President Eisenhower.

CIVIL AVIATION

VARIG DECIDES ON CARAVELLES

FOR many months now the Brazilian international airline VARIG of Porto Alegre have been watched closely as keen prospective purchasers of medium haul equipment. During this time the usual number of contending designs have been examined. Last week the airline announced that it had ordered two Sud-Aviation Caravelles, with an option on three. The aircraft are to be delivered in June and November 1959, at a cost of about $5m. VARIG may use Caravelles on its route to New York until they take delivery of their three Boeing 707s in 1960. After that the Caravelles will be used to connect Rio de Janeiro with Buenos Aires and Montevideo, and with Belem, Recife, Salvador, Sao Paulo and Porto Alegre in Brazil.

VARIG's order is a major success for the French industry, and is the first fruit of the Caravelle's successful tour of North and South America during the summer. An interesting point about the contract is that the Rolls-Royce Avon RA.29s to be fitted to these Caravelles will be rated at 11,700 lb. The usual Caravelle rating is 11,000 lb, and the initial Comet 4 and 4B rating is 10,500 lb.

TOWARDS A COMMON CODE

THE ideal of one international airworthiness code, so strongly advocated by airlines and manufacturers, is still far from being realized. But during the summer, the Air Registration Board and the American Civil Aeronautics Administration have been comparing, line by line, these two principal national codes in an attempt to highlight the differences. Negotiations to narrow these differences are now going on in Washington between the A.R.B. and the C.A.A., the British delegation being led by Mr. R. E. Hardingham, Secretary of the A.R.B.

A real step towards reducing the number of "special conditions" which each side (usually, so far, the C.A.A.) makes before validating the other's C. of A. was recorded last August, when the C.A.A. adopted a new performance code for turbine aircraft which followed, in its principles at least, that of the A.R.B.

I.A.T.A.'s FARE INCREASES

ALTHOUGH I.A.T.A. could not agree at Miami on the new north Atlantic rate structure, and delegates had to take a breather before resuming their discussions in Paris on November 19, they did agree fully about rates elsewhere in the world.

First-class fare increases of up to seven per cent on a large number of routes (except of course the north Atlantic) were recommended, although tourist fares, with a few exceptions, were left unchanged. The proposed increases have been expected by the governments concerned, and it would be surprising if—as the American government has done with the recommended north Atlantic increases—they were to reject them. The airlines have been at pains to point out during the past year the effect of inflation on their budgets, and some have even hinted at falling back on subsidies. Wisely, I.A.T.A. have left the prices of tourist travel—which is steadily increasing its 40 per cent share of the total world airline business—largely unchanged. Therein lies the airlines' future big market, and they do not want to price themselves out of it.

The recommendations, which include some cargo increases of up to ten per cent, are as follows:

Mid-Atlantic Tourist class fares between Central America and Europe will remain unchanged. First class fares will go up $20.

South Atlantic First and tourist fares between South America and Europe will be increased three per cent. Emigrant fares from some European countries will be introduced.

Europe, Middle East and Africa Adjustments to individual fares resulting in some cases in increases of up to five per cent. The present promotional excursion fare programme will be continued and some new items added.

Europe, India, Far East and Australia Little or no change in fares between Europe and India. Increases of four to five per cent on tourist class and six to seven per cent on first-class services between Europe and the Far East and Australia, but no increase on the Europe-Australia fare.

Asia, Australia and the Pacific Generally unchanged with some increases, largely on first-class services.

Trans-Pacific Fares over the North and Mid-Pacific routes unchanged. On the South Pacific route no change in tourist fares and a five per cent increase on first-class services.

Round the world and polar fares No change.

THE MINISTER AND THE PROTEUS

AS reported last week, there appear to be hopeful signs that the final answer to the Proteus engine's icing problem may be within sight. At Belfast last week the Minister of Supply, Mr. Aubrey Jones, said: "Speaking with all the caution with which ministers sought to invest their utterances, I think that a real and by no means over-elaborate solution may be in sight, and may be capable of being applied more rapidly than might have been thought possible even a short time ago. This approach to the problem is being put in hand with all possible energy, both by the Royal Aircraft Establishment and by Bristols."

BELFAST TRAGEDY

IT is with great regret that *Flight* records an accident to the flagship of B.E.A.'s Viscount 802 fleet, which occurred on the afternoon of October 23 at Nutts Corner, Belfast. The aircraft, Viscount 802 G-AOJA *Sir Samuel White Baker*, was approaching the airport under G.C.A. control in low cloud and rain when it struck the ground and was completely destroyed. There were a crew of five and two passengers (a B.E.A. official and his wife) on board, all of whom lost their lives. The Viscount was not on a scheduled passenger service, but was on a special flight from London. It was to have picked up the Minister of Supply, Mr. Aubrey Jones, and a party of journalists who had been attending the opening of the new research department at Short Brothers and Harland, Ltd. As *Flight* went to press, the Minister had not yet decided whether a public inquiry should be held.

B.E.A.'s RECORD MONTH

"AN all-round and sustained restraint" in expenditure, says Lord Douglas, chairman of B.E.A., largely contributed to the £1m profit made by the Corporation during August. This was the highest monthly actual profit achieved (it is not to be confused with the £1m net profit which the chairman estimated in September had so far been recorded during the financial year).

Another record broken in August was the number of passengers carried, which reached 402,573. Total traffic increased 18.2 per cent compared with August 1956.

Although more staff were taken on to cope with the summer business, their numbers had been limited, and productivity was actually 12 per cent higher than in August 1956. This, more than anything, apparently contributed to the improved financial results.

CIVIL AVIATION . . .

Alighting from the Comet 3 at Johannesburg on October 23 are D.H. chief test pilot John Cunningham with Comet test pilots Peter Wilson (left) and Peter Bugge (right). They had just set up a new record for the London - Johannesburg route of 12 hr 58 min 57.3 sec, at an average speed of 434 m.p.h. including a 53 min stop at Khartoum—the Comet's second record in a week. Purpose of the flight was to make field performance tests at Jan Smuts; these will complete 90 per cent of the certification flying for the production Comet 4. The Comet 3's next job will be to assess the clipped-wing performance of the 4B.

BREVITIES

THE Portuguese airline T.A.P. announces that it has ordered Viscount 810/840s. It is understood that the order amounts to three aircraft, bringing total Viscount sales up to 378. Another new Viscount operator will be TACA of San Salvador, who have leased one from Philippine Air Lines for use on their routes between Central America and New Orleans and Mexico City.

* * *

The Export/Import Bank has agreed to lend Air France about $61m to help finance the airline's order for 17 Boeing 707-320s. A further $17.5m will come from U.S. banks.

* * *

The Frye Safari, which still awaits production, may be built by "one of the best-known European manufacturers," according to Mr. Jack Frye. He gives the Safari's selling price as "from $650,000."

* * *

The Viscount 806-810 which was damaged on a test landing at Johannesburg on October 20 needs a new starboard wing, undercarriage and engines. These will be flown out from England.

* * *

The New Zealand magazine *Whites* reports that N.Z.N.A.C. are considering Armstrong Whitworth A.W.670s for the Cook Strait service. A minimum of two aircraft would be required. The cost of the A.W.670 is quoted by the airline at £375,000 and the "estimated minimum capital required to operate two aircraft" is £1,113,000.

* * *

Now officially opened by the High Commissioner for Australia, Sir Eric Harrison, are the new Qantas premises at 57/58 Piccadilly and 50 Old Bond Street, W.1.

* * *

Hopes that Napier's Eland-converted Convair 340 may begin its U.S. certification tests earlier than expected (see page 708) were raised as *Flight* went to press. It is now hoped that the aircraft will begin its C.A.A. trials in California before the end of this year.

* * *

The first order for the Grumman Gulfstream, the new twin-Dart executive, has been placed by the Sinclair Refining Company of Tulsa. Delivery will be made in late 1958 and the cost is likely to be $700,000.

* * *

Short's advocacy of the turboprop for cheap air transport is the background to their new project, which has Britannia wings and parts, with big capacity for freight (up to 60,000 lb) and 192 coach seats. Bristol Orions may be used; cruising speed is about 400 m.p.h.; max. range 5,500 m.; d.o.c. 6d/ton-m. Production deliveries could be made before the mid-sixties.

UNDER THE CEDAR TREE (continued from page 668)

then reported that, in his opinion, everything was so finely balanced that any adjustments would be most unwise, and as we seemed to be getting along very well, we should stay the way we are."

Upon this economy, current civil aviation growth in the Middle East of 22 per cent per annum, and the potential of business travel and carriage of air freight, Middle East Airlines have built up their fleet since May 1945 from three Rapides and two DC-3s to five Viscounts, three Yorks, a Bristol Freighter and four DC-3s; and the company is now actively studying re-equipment for the 1960s, with the Vanguard a favourite for first-line services and the Dart and the Herald under consideration as a DC-3 replacement.

During this period M.E.A. have relied upon the help and experience of more senior airlines; in 1949 PanAm acquired 36 per cent of the shares and three of the seven seats on the board, in exchange for three Dakotas and spare parts. Later, when this marriage was dissolved in 1955 over the question of acquiring modern equipment, an association with B.O.A.C. was formed. Under this later liaison (which has proved a happy one), the Corporation acquired 48 per cent of M.E.A. shares and four of the eleven seats on the board. In preparation for Viscount 732s acquired from Hunting Clan the airline rather prematurely disposed of some of its DC-3s and operated Hermes during the summer of 1955 until its first turboprops arrived. Thus equipped, they immediately opened services to Athens and Rome and later —when another aircraft (from Fred Olsen) joined the fleet in April 1956—to Paris, London, Vienna and Zurich. Further expansion, which included the addition of Yorks and Freighters, was backed by an increase in capital to £715,000 and the fleet was brought up to five Viscounts in August 1957. Those chartered from Hunting Clan (and now returned to them) were replaced by the 754s which had been ordered by B.O.A.C.; and in December, when the fourth new aircraft arrives, the Olsen aircraft will be returned. The 754s (equipped for weather radar) have an interior layout of 48 seats placed four abreast, with the galley aft and two toilets on each side forward. This gives a pleasantly wide aisle and seats at 34in pitch; rather close for tall people, but an arrangement that I (and I think most other passengers) find preferable to five seats abreast. The seats are also rather less high than those used in B.E.A. aircraft and give an effect of greater spaciousness in the red and grey cabin.

Introduction of the Viscount, and the blessing of B.O.A.C., gave Middle East the impetus they needed, and their unduplicated route mileage increased from 4,500 miles a year in 1954 to 16,500 in 1957. In the last quarter of 1956 the engineering department of the airline was detached to form the Mideast Aircraft Servicing Company (MASCO), of which 65 per cent of the capital is British and 25 per cent Lebanese. The significance of this move is considerable, since the new company, which has a Lebanese, Arab and British shareholding, is offering servicing facilities for all the airlines in the area. They are constructing a Dart overhaul shop and will be a source of Rolls-Royce spares in the Middle East.

The worth of such an organization was emphasized to visitors to M.E.A. by Sheik Najib Alamuddin, the chairman and managing director, when he gave details of some of his airline's equipment hopes and problems in the years ahead. Spread around his office were models of the aircraft his airline is studying. "Our first choice," he said, "is to continue the Rolls-Vickers combination with the Vanguard" (the model of which was in M.E.A. colours and registered OD-SMA). Delivery would be in 1961-2, so that M.E.A. could benefit from the experience of other airlines. "Since with Vanguards we should run into flight time limitations, we might put crew bunks into the underfloor holds, which we should certainly have a great deal of use for in developing the cargo traffic which we allowed to lapse while Viscount services developed. The Electra is another prospect; the Lockheed people have been to see us and we are also studying the Comet and Caravelle. With big markets still to be tapped," the chairman added, "and with the prospect of lower fares and political stability, we are planning our expansions in every direction, and we hope soon to replace our DC-3s with Heralds or Friendships."

Air Leban, on the other hand (they are to operate in pool with M.E.A.) bought a DC-6 because no Viscounts were available; and although they may still buy Viscounts they are considering Caravelles for the 1960s. In any case, there would be plenty of Rolls-Royce engine overhaul business for MASCO.

There seems to be plenty of scope for this sort of enterprise in the Lebanon: no restriction has been placed on the local capital that may be invested in M.E.A., and B.O.A.C. are willing to withdraw their interest progressively as Lebanese support increases. A similar arrangement is likely to be made between Sabena and Lebanese International Airways, to whom the Belgian line has chartered an aircraft. Perhaps the best example of what can be done is that of a 27-year-old employee of M.E.A. who formed Trans-Mediterranean Airways three years ago and now operates seven Yorks throughout the Middle East.

"Flight" photograph

At Boscombe Down before the demonstration referred to below, a C-130 Hercules—showing loading door—with a Beverley just beyond it.

SERVICE AVIATION

Royal Air Forces and Naval Aviation News

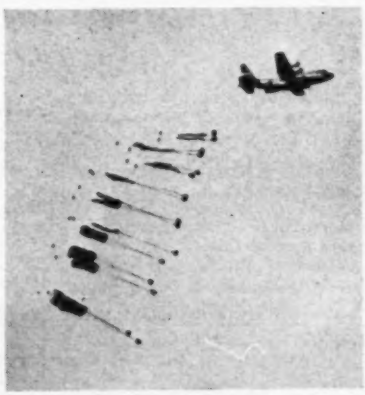
R.A.A.F. Changes

SEVERAL changes in senior posts have been announced by the R.A.A.F. A.V-M. A. L. Walters, formerly A.O.C. Home Command, has been appointed Air Member for Personnel from October 21. He is to be succeeded at Home Command by A.V-M. C. D. Candy, at present Deputy Chief of the Air Staff; but as this appointment will not take effect until next January the post is being filled temporarily by A. Cdre. G. C. Hartnell. When A.V-M. Candy takes over he will be succeeded as D.C.A.S. by A.V-M. A. M. Murdoch.

Hercules Demonstration

SIXTEEN tons of fuel oil in A.22 containers, supported by sixteen olive-green parachutes, floated down to a dropping-zone on Salisbury Plain from the Lockheed C-130 Hercules *Ville de Fauville* on October 22. This was the first time the Hercules (12 of them have been ordered by the R.A.A.F. and it is replacing the C-119 as standard equipment for the U.S.A.F. 317th Troop Carrier Wing at Evreux A.F.B. in France) had given a supply-dropping demonstration in this country. On view beforehand with it at Boscombe Down—for the air transport systems working party of the Anglo-Canadian-American Air Standardization Co-ordinating Committee — were two Beverleys, a C-119 and a Comet.

For such a workhorse type of aeroplane—its fuselage has a main compartment 41.4ft long and almost square (10.2ft wide and 9.1ft deep) and maximum payload is given as 39,400 lb—the Hercules [fully described in *Flight* for September 14 last year] is remarkably graceful. Its single fin rises dramatically to 38.3ft from ground level, the four Allison T56-A-1 turboprop powerplants are cowled with remarkable neatness, and the main undercarriage housing—a long bulge at each side of the fuselage—does not seriously detract from the generally smooth but pugnacious Herculean lines.



Viewed at rest, one's first impression is that the C-130's fuselage is almost on the ground. (The main loading door at the rear lowers to 3.4ft—"truck bed height," as the Americans say.) The four main wheel tyres are of such low pressure—varying from 50 to 70 lb—that they look flat. These low pressures assist weight distribution when taking off from soft fields or uneven surfaces; as a crewman put it, "You could put a milk bottle down on the runway and that airplane would run over it without hurting it." The Hercules is completely pressurized and can carry 92 soldiers or 64 paratroops or up to 74 stretcher cases.

There are at present six squadrons of C-130s in the U.S. and there will eventually be three in Europe. The Hercules which took part in the dropping demonstration on October 22 belonged to the 781st, which has two C-130s and is being re-equipped entirely with them in place of its C-119s. The two other squadrons in the same Wing, Nos. 780 and 782, will be similarly re-equipped.

IN BRIEF

R.A.F. Oldenburg in West Germany was ceremonially handed over to the German Air Force on October 21.

* * * * *

Ilford 4F Squadron, representing the West Essex Wing and the Eastern Region, won the Air Training Corps aircraft recognition championship at R.A.F. Hendon last Sunday. They scored 67 points. The Scottish Region, represented by Glasgow, were second with 52; and the Welsh Wing third with 51 points.

* * * * *

Three choral scholarships, of £80 a year each, are to be offered to sons of members of the R.A.F. (or of Air Ministry civilian staff) who join the choir at the R.A.F. Church of St. Clement Danes. These scholarships are being provided under a scheme sanctioned by the managing trustees of the appeal fund, and applications should reach the Secretary, St. Clement Danes Finance Committee, c/o Chaplain-in-Chief, Air Ministry, Turnstile House, High Holborn, London, W.C.1, by November 9.

Above, a stick of 16 one-ton containers just after release from the Hercules at 1,000ft; below, left, the distribution of this 35,840 lb load in the aircraft's cargo compartment; and below right, the containers nearing touch-down at the Figheldean D.Z., where the demonstration was held.

"Flight" photographs

CORRESPONDENCE

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

South Coast Alternative to Croydon ?

I WAS most interested in, but rather saddened by, the article "Croydon Under Sentence" in *Flight* of September 27. If, as now seems probable, the sentence is confirmed, and the present tenants are given notice to quit, I wonder if they know that the Hastings Corporation are extending and going to develop the municipally owned Hastings (Pebsham) Aerodrome? The Corporation hope to have two grass runways, one N.E.-S.W. of 1,000 yd (ultimately 1,500 yd) and another S.E.-N.W. of 800 yd, in use by 1960. If, however, some operators showed a firm interest in the aerodrome then no doubt the Corporation would agree to speed up the work and complete it by an earlier date.

Pebsham would be an ideal base for charter operations, for medium-aircraft scheduled services to the Continent, and for light, club, and school flying, as it has a good all-the-year-round weather record. Hastings now has a faster rail link with London, using the new diesel-electric trains; and there would also be little or no interference with the air traffic control zones as it lies right between Blue airways 1 and 3 (Seaford and Rye). There is plenty of room around the aerodrome perimeter for hangars, workshops and allied industrial activities.

With far-sighted, proper and vigorous development the aerodrome has a great future.

Bexhill-on-Sea, Sussex. HUGH A. GORDON.

Missiles and the Moon

FROM your report (October 25) of the Barcelona Astronautics Congress I see that Prof. Singer of Maryland University suggests (apparently in all seriousness) that as "the technical ability to shoot ballistic missiles to the Moon is now almost within reach," that heavenly body should be used as a target for H-bomb missiles, thus "doing away" with the present hazards of making such tests on Earth.

In this connection it is not, perhaps, irrelevant to quote the dictionary definition of the word lunatic: "affected by the Moon; temporarily insane."

My only comforting thought on reading of such things is that when one of these experiments comes unstuck (which on present form, to judge from current reports of U.S. missile launchings, seems an even chance), our Moon-affected scientists may well be there with the rest of us to welcome back the H-bomb that fails to reach its planned destination.

London, W.1. PESSIMISTICUS.

Underneath the Arches

REFERRING to the letter from Mr. Maurice Austin (September 20), he may be interested to hear that I have had the doubtful pleasure of flying, after take-off, under Willingdon Bridge, Calcutta. The aircraft was known then as a "giant" C-class flying-boat. It was, as far as I remember, fully laden with astonished crew and passengers and was captained by a well-remembered D. C. T. Bennett.

West Drayton, Middx. RADIO OFFICER.

I SAW a Tiger flown through a blister hangar without touching the sides, at Alton Barnes [near Devizes] early in 1944. The curtains were open, of course, but there was very little room to spare.

The pilot, who was instructing there at the time, had just been told that he was posted!

London, S.E.12. D. R. BEVIS.

Personality from the Past

I WAS interested in the letter in your issue of September 6 headed "The Mysterious M. Bellamy." In 1934 I was instructing at Gravesend and one of my pupils was a Mr. Bellamy. He told me that he was one of the earlier experimenters in aviation and said that he had never got any of his designs to fly, due to trouble with the propellers. His description of the type of airscrew he used was almost identical with that described by your correspondent Mr. Hammond. It makes me feel that my pupil and the mysterious M. Bellamy were one and the same.

I sent him solo in a Moth when he was well over 70 years of age. He took an "A" licence and subsequently purchased a British Klemm for his private use. I believe he also purchased a C.30 Autogiro later on.

Nicosia, Cyprus. P. HOLROYD SMITH.

THE INDUSTRY

AN American subsidiary, Rotol Inc., has been formed by Rotol, Ltd. Its main function will be to render after-sales service and technical assistance to airline operators and aircraft manufacturers using Rotol and British Messier equipment in the Americas. Headquarters will be in Washington, on the Jefferson Davis Highway, and the facilities are due to come into operation next January. The president will be Mr. Jack Staples, who was formerly deputy sales manager of Rotol and British Messier. The parent company is to be represented on the Board of the American subsidiary by Lt-Gen. Sir John Evetts, managing director of Rotol, Ltd., as chairman; and by Mr. C. J. Luby (assistant managing director) as a director.

* * *

Viscount Knollys, chairman of Vickers, Ltd., is in South America. He will visit Venezuela, Colombia, Peru, Chile, Argentina, Uruguay and Brazil before leaving for home on November 30.

* * *

Sir Harry Railing has resigned as chairman and joint managing director of the General Electric Co., Ltd., having held those positions since 1943. He will remain on the Board but as from today is succeeded in the chairmanship and as joint managing director by Mr. Leslie Gamage, vice-chairman and managing director, who has been on the Board since 1925, when he assumed responsibility for the company's export business.

* * *

The diamond jubilee of Ross, Courtney and Co., Ltd., was celebrated on October 23 with the opening of a new extension to the company's factory at 25 Ashbrook Road, Holloway, London, N.19, by the chairman, Lord Gridley, K.B.E., M.I.E.E. The company, which manufactures wiring accessories and a variety of mechanical and electrical detail components, and employs approximately 150 people, is one of nine subsidiaries of Southern Areas Electric Corporation, Ltd., 28 Queen Anne's Gate, London, S.W.1.

* * *

Some senior engineering changes have been announced by Orenda Engines, Ltd. Mr. F. Harry Keast, formerly deputy chief engineer, has been appointed chief engineer with full technical responsibility for engineering activities; Dr. Alex Muraszew (until now chief experimental engineer) becomes deputy chief engineer, responsible for the development department, experimental shop and the company's test establishment at Nobel, Ont; and Mr. Burt A. Avery (formerly chief design engineer) becomes deputy chief engineer responsible for the design, aerodynamics and material departments.

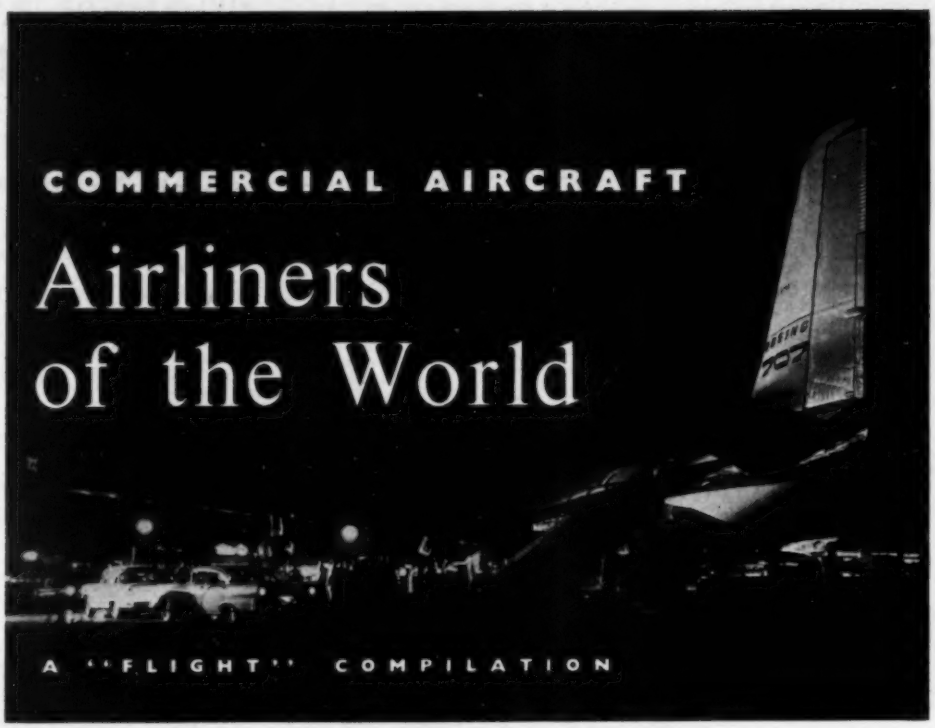
* * *

Chloride Batteries, Ltd., the makers of Exide batteries, are establishing a new research and development department near their main factory at Clifton Junction, Manchester. To be completed during the coming year, it will enable them to concentrate the research work of their whole group of companies.

* * *

Formerly research director in semiconductors and solid-state physics for the Northern Electric Co., of Montreal, Dr. James Reekie, B.Sc., Ph.D., A.M.I.E.E., F.R.S.E., has been appointed chief engineer to Semiconductors, Ltd., Ilford, Essex. He has spent the last twelve years in Canada, first as Professor of Physics at the University of Toronto and then (before joining Northern Electric) as head of the Department of Physics at the Royal Military College. Semiconductors, Ltd., is controlled jointly by the Plessey Co., Ltd., and the Philco Corporation of America.

Mr. R. E. Harvey (left) and Mr. H. G. Conway, who—as recorded last week—have been appointed joint deputy managing directors of Short Brothers and Harland, Ltd.



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THIS is *Flight's* second review of the world's commercial aircraft. Special prominence is given to the turbine-powered transports which—varying in traffic-carrying capacity from the Friendship and Herald to the DC-8 and 707—are now competing for the favours of the world's airlines.

Since the last review, on July 6, 1956, there have been many detailed changes to almost every one of these aircraft. The design and operating data, *Flight's* engineering cutaway drawings and the descriptions of every type have been revised with the co-operation of the makers. So far as possible we have endeavoured to present the information in a standardized form, though this has not been easy (and is, indeed, not always desirable) in view of the varying and perplexing manner in which manufacturers offer the same type of information.

This is probably a reflection of the fundamentally original approaches which the American, British, French and Dutch (and now the Russian) industries make towards the fashioning of the "ideal" vehicle for a particular market. The classical controversy is, of course, jet *versus* turboprop: like all stimulating controversies it may never be settled, but it will at any rate result in the full realization of the benefits which each side offers.

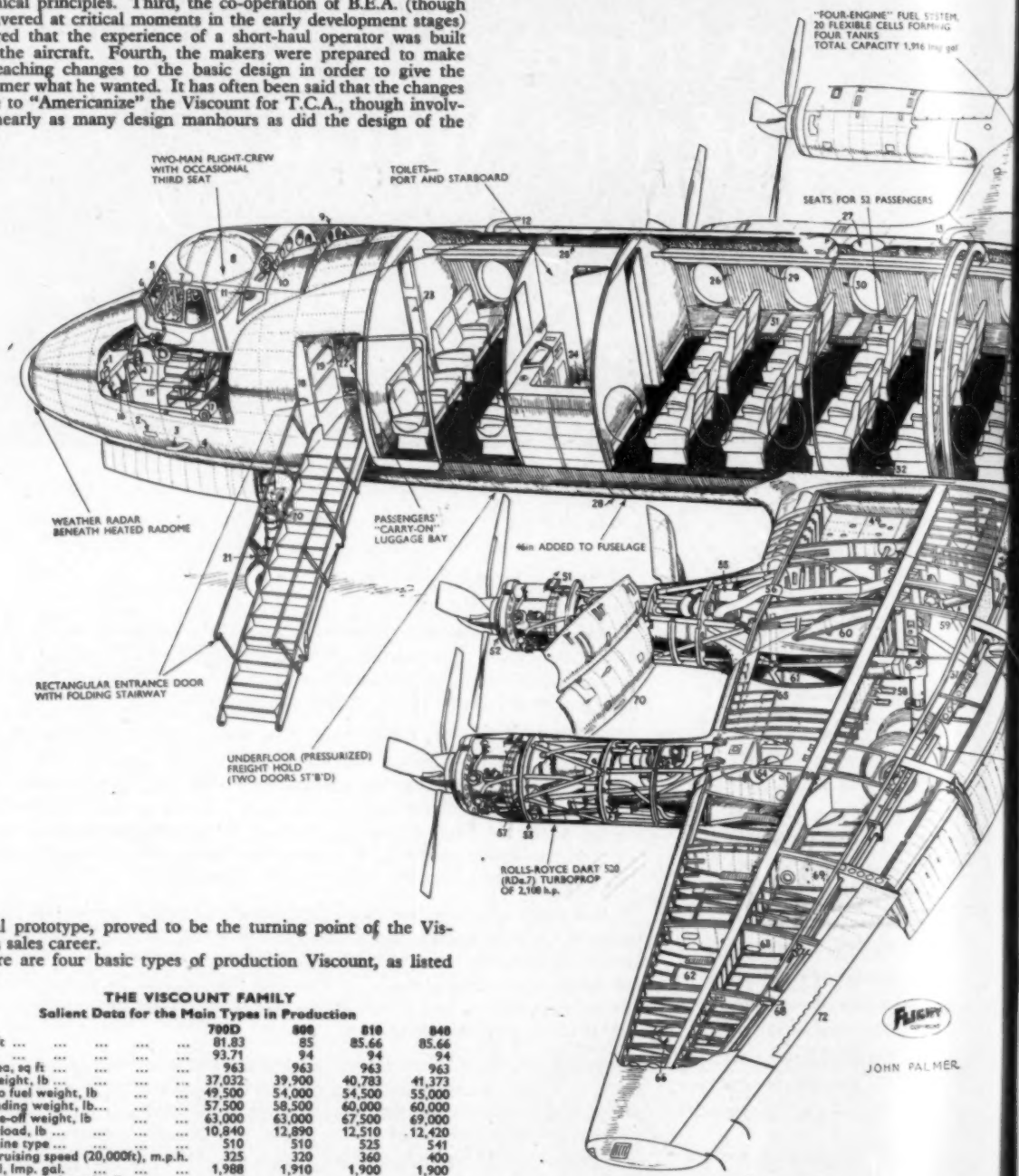
There is no lack of choice before the airlines; and many may feel, on studying these pages, that success cannot come to every type. But reaching before each one, starting in the magic year 1960, may perhaps be two decades of mounting international air commerce. And if the nations of the world continue to take an enlightened view of the way aviation should be used, there may be room for all these aircraft—at least until the supersonic transport era begins.

AIRLINERS OF THE WORLD

VISCOUNT 810

Vickers-Armstrongs (Aircraft), Ltd.
Weybridge, Surrey.

Drawn at Weybridge, 1956, revised October, 1957.


"FOUR-ENGINE" FUEL SYSTEM, 20 FLEXIBLE CELLS FORMING FOUR TANKS TOTAL CAPACITY 1,916 Imp. gal
TWO-MAN FLIGHT-CREW WITH OCCASIONAL THIRD SEAT
TOILETS—PORT AND STARBOARD
SEATS FOR 52 PASSENGERS
WEATHER RADAR BENEATH HEATED RADOME
PASSENGERS' "CARRY-ON" LUGGAGE BAY
46in ADDED TO FUSELAGE
RECTANGULAR ENTRANCE DOOR WITH FOLDING STAIRWAY
UNDERFLOOR (PRESSURIZED) FREIGHT HOLD (TWO DOORS ST'B'D)
ROLLS-ROYCE DART 520 (RDa.7) TURBOPROP OF 2,100 h.p.
JOHN PALMER

THE Viscount has become the symbol of the British aircraft industry's aspirations to challenge the American industry's domination of the world's transport aircraft market. Looking back on the Viscount's remarkable career, in the course of which the aircraft has been ordered by no less than 47 operators in 31 countries, it is possible to detect the main ingredients of success. First, the concept of a medium-sized propeller-turbine airliner was a relatively short technical step, rather than a bold leap ahead. Second, the turbine engine chosen was—in accordance with Rolls-Royce principles—a good piece of rugged engineering, built to known and understood precepts rather than to promising but (at that time, i.e. just after the war) uncharted technical principles. Third, the co-operation of B.E.A. (though it wavered at critical moments in the early development stages) ensured that the experience of a short-haul operator was built into the aircraft. Fourth, the makers were prepared to make far-reaching changes to the basic design in order to give the customer what he wanted. It has often been said that the changes made to "Americanize" the Viscount for T.C.A., though involving nearly as many design manhours as did the design of the original prototype, proved to be the turning point of the Viscount's sales career.

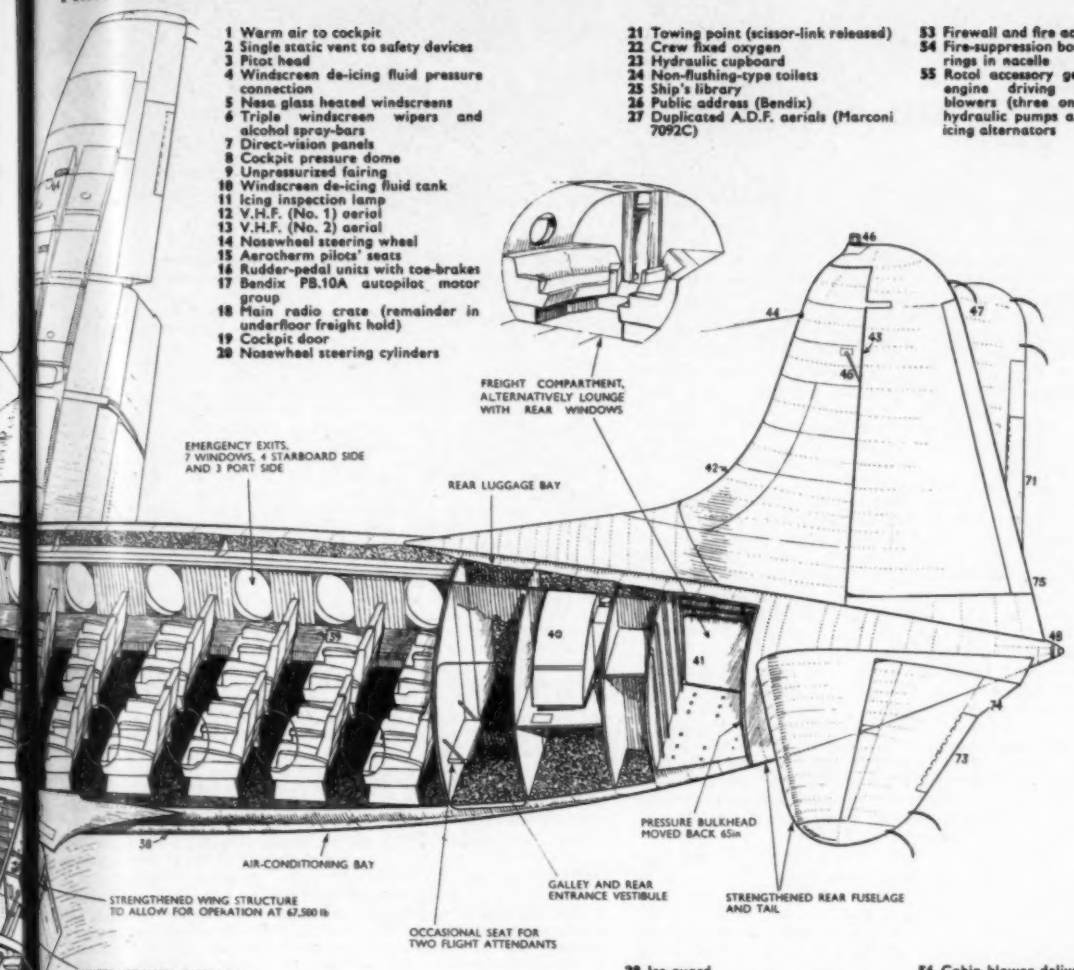
There are four basic types of production Viscount, as listed below.

THE VISCOUNT FAMILY
Salient Data for the Main Types in Production

	700D	800	810	840
Length, ft	81.83	85	85.66	85.66
Span, ft	93.71	94	94	94
Wing area, sq ft	963	963	963	963
Empty weight, lb	37,032	39,900	40,783	41,373
Max. zero fuel weight, lb	49,500	54,000	54,500	55,000
Max. Landing weight, lb...	57,500	58,500	60,000	60,000
Max. take-off weight, lb	63,000	63,000	67,500	69,000
Max. payload, lb	10,840	12,890	12,510	12,420
Dart engine type	510	510	525	541
Typical cruising speed (20,000ft), m.p.h.	325	320	360	400
Total fuel, Imp. gal.	1,988	1,910	1,900	1,900
No. of passengers (standard)	44	52	52	52
Max. payload range*, st.m.	1,110	500	960	1,100
Typical take-off field length, ft	5,150	5,150	5,350	5,300

*Reserves include: 45 min holding at 5,000ft and a 230 st. m. diversion.
Note: Performance figures are for typical standard conditions.

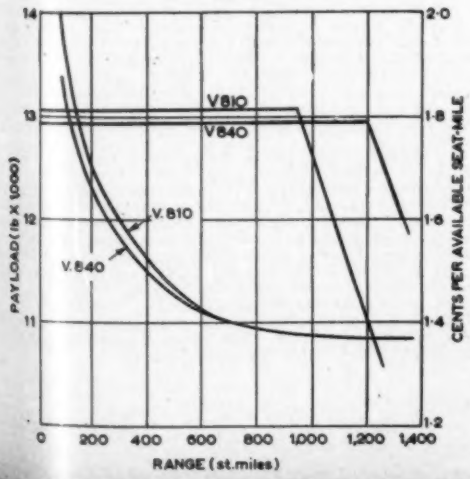
The description which follows relates to the Viscount 810/840. This version makes use of the higher powered Dart R.Da.7 Series of 1,990 e.h.p., giving considerably higher available cruising power than previous Viscounts. The cruising speed of the 810 is some 40 m.p.h. more than previous Viscounts; and the designation 810/840 indicates that the structural changes made to accommodate the increased power of the R.Da.7 are, in fact, sufficient to


FREIGHT COMPARTMENT, ALTERNATIVELY LOUNGE WITH REAR WINDOWS
EMERGENCY EXITS, 7 WINDOWS, 4 STARBOARD SIDE AND 3 PORT SIDE
REAR LUGGAGE BAY
PRESSURE BULKHEAD MOVED BACK 65in
AIR-CONDITIONING BAY
GALLEY AND REAR ENTRANCE VESTIBULE
STRENGTHENED REAR FUSELAGE AND TAIL
STRENGTHENED WING STRUCTURE TO ALLOW FOR OPERATION AT 67,500 lb
OCCASIONAL SEAT FOR TWO FLIGHT ATTENDANTS
WATER-METHANOL TANK BAY 55 Imp gal EACH SIDE
DOUBLE-SLOTTED FLAPS
STRENGTHENED UNDERCARRIAGE AND BRAKES WITH HIGHER ENERGY ABSORPTION

1 Warm air to cockpit
2 Single static vent to safety devices
3 Pitot head
4 Windscreen de-icing fluid pressure connection
5 Nose glass heated windscreens
6 Triple windscreen wipers and alcohol spray-bars
7 Direct-vision panels
8 Cockpit pressure dome
9 Unpressurized fairing
10 Windscreen de-icing fluid tank
11 Icing inspection lamp
12 V.H.F. (No. 1) aerial
13 V.H.F. (No. 2) aerial
14 Nosewheel steering wheel
15 Aerotherm pilots' seats
16 Rudder-pedal units with toe-brakes
17 Bendix PB.10A autopilot motor group
18 Main radio crate (remainder in underfloor freight hold)
19 Cockpit door
20 Nosewheel steering cylinders
21 Towing point (scissor-link released)
22 Crew fixed oxygen
23 Hydraulic cupboard
24 Non-flushing-type toilets
25 Ship's library
26 Public address (Bendix)
27 Duplicated A.D.F. aerials (Marconi 7092C)
53 Firewall and fire access panels
54 Fire-suppression bottle; three spray rings in nacelle
55 Rotol accessory gearbox on each engine driving Godfrey cabin blowers (three only), generators, hydraulic pumps and airscrew de-icing alternators

28 Ice-guard
29 Passengers' service panel under light luggage rack
30 Sliding curtains (no sunblinds)
31 Chair-back tables
32 Emergency exit external release
33 Flap motor and gearbox
34 Flap torque tube and driving chains
35 Flap guide rails and radius arms
36 Aileron control pressure-seal
37 Aileron control run
38 Intercooler airflow (flush intake)
39 Conditioned-air duct
40 Galley equipment
41 Baggage bay door
42 Double-skinned leading edge of wing, fin and tailplane
43 De-icing air outlets
44 H.F./Loran aerial (for ferry only)
45 V.O.R. and I.L.S. localizer aerials
46 "Pounder"-type anti-collision beacon
47 Static dischargers
48 Navigation lights
49 Tank-bay linings perforated for rubber retaining studs.
50 Bag-type fuel tanks
51 Airflow through oil cooler
52 Electric de-icing pads
56 Cabin blower delivery duct (intake on nacelle inner flank)
57 Main engine mounting point
58 Vickers 14in-stroke undercarriage. Dunlop tyres, wheels, steel-disc brakes with Maxaret
59 Retraction jack
60 Retraction bay and door linkage
61 Jet-pipes
62 Tank-access panels
63 Pacitor gauge covers
64 Float-switch covers
65 Gravity-filling points (pressure refuelling below wing)
66 Landing lamp
67 Access to outer-plane attachment bolts
68 Irving-balanced split ailerons, skew-bar operated
69 Nine ribs only in each wing, plus light chordwise members
70 Outer cowling petal with hinged top section; inner carries lower cowling
71 Trim tabs
72 Balance tab
73 Anti-balance tab
74 Spring/servo tab
75 Servo/trim tab

Payload-range performance (upper) and operating costs for the Viscount 810/840. Payload-range is for I.S.A. conditions and max. payloads (including catering and four crew) limited by zero fuel weight, and includes reserves for taxying, take-off and landing; 45 min. holding at 5,000ft, and 230 st.m. diversion. The cost curves are calculated to the Lockheed method, slightly modified to suit the British aircraft.



take the even higher power offered by the R.Da.11 Dart engines (Mark 541). The power offered by this 2,350 e.h.p. Dart development can thus be utilized by the basic 810 airframe, which is then designated 840. This is the true 400 m.p.h. Viscount.

AIRFRAME The Viscount 810/840 airframe differs from previous models in the general strengthening made to increase the structural I.A.S. limit by about 50 m.p.h. In general, these changes are: (1) strengthened nacelles; (2) strengthened wing rib and spar structure and heavier gauge skin in the inner wings; (3) strengthened undercarriage and higher-energy-absorption brakes; (4) reinforced rear fuselage to withstand higher tail loads; (5) stronger tail; (6) horn-balanced rudder for more powerful control.

Fuselage Open channel frames are notched to receive angle stringers to which the skin is flush riveted. The complete fuse-

AIRLINERS
OF THE WORLD

VISCOUNT 810...

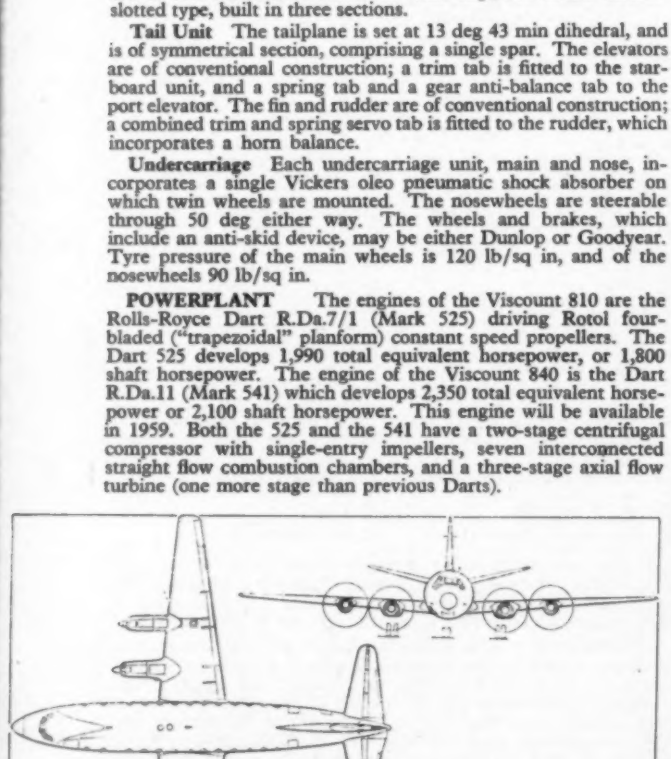
lage is built as one unit between the pressure bulkheads. Overall floor loading is 100 lb/sq ft, with 150 acceptable in certain areas. The passenger windows, 26 in number (or 28 with a rear lounge) are vertical ellipses measuring 26in by 19in. Six windows above the wing are emergency exits, together with another window forward to the starboard. Whereas earlier Viscounts had elliptical doors, the 810—like the intermediate 800 series—has rectangular doors with rounded corners. The main passenger entry door measures 64in by 36in, is situated forward of the wing on the port side, and can incorporate a power-folding airstair. It is hinged at the rear edge (parallel motion). On each side of the aircraft two further doors at the aft end can be used as emergency exits or for passenger loading. They measure 64in by 27in each and are similarly hinged. Two further doors, on the starboard side forward of the wing and below floor level, provide access to the under-floor freight hold. There is provision also for a further door on the starboard side at the extreme aft end for access to the rear freight compartment (this area is available as a lounge).

Wing Each wing is built up in three sections: inner, outer and a detachable tip. The nacelles are mounted on the inner section. Flexible fuel tanks are fitted in both inner and outer sections, and a water/methanol tank in each inner section. Thickness chord ratio is 15.5 per cent at the root and 13 per cent at the tip. The primary structure consists of a main spar at 0.4 of the wing chord and subsidiary spars at 0.05 and 0.7 chord. The spars, together with the top and bottom skin panels, complete the torsion box. The main spar of each inner section is attached to the fuselage by control-interference fit taper bolts; the subsidiary spar members are each attached to the fuselage by four bolts. The ailerons are each built in two sections to avoid hinge friction, and are of conventional construction. The flaps are of the double-slotted type, built in three sections.

Tail Unit The tailplane is set at 13 deg 43 min dihedral, and is of symmetrical section, comprising a single spar. The elevators are of conventional construction; a trim tab is fitted to the starboard unit, and a spring tab and a gear anti-balance tab to the port elevator. The fin and rudder are of conventional construction; a combined trim and spring servo tab is fitted to the rudder, which incorporates a horn balance.

Undercarriage Each undercarriage unit, main and nose, incorporates a single Vickers oleo pneumatic shock absorber on which twin wheels are mounted. The nosewheels are steerable through 50 deg either way. The wheels and brakes, which include an anti-skid device, may be either Dunlop or Goodyear. Tyre pressure of the main wheels is 120 lb/sq in, and of the nosewheels 90 lb/sq in.

POWERPLANT The engines of the Viscount 810 are the Rolls-Royce Dart R.Da.7/1 (Mark 525) driving Rotol four-bladed ("trapezoidal" planform) constant speed propellers. The Dart 525 develops 1,990 total equivalent horsepower, or 1,800 shaft horsepower. The engine of the Viscount 840 is the Dart R.Da.11 (Mark 541) which develops 2,350 total equivalent horsepower or 2,100 shaft horsepower. This engine will be available in 1959. Both the 525 and the 541 have a two-stage centrifugal compressor with single-entry impellers, seven interconnected straight flow combustion chambers, and a three-stage axial flow turbine (one more stage than previous Darts).



SYSTEMS **Flying Controls** The flying controls are conventional in design and operate the control surfaces through push-pull rods and levers.

Fuel System The fuel system is designed to use British, American and Canadian grades of either kerosine or wide-cut gasoline. The fuel is carried in the wings, in a total of four tanks, each consisting of a number of interconnected flexible bag type cells. Usable fuel capacity of each outboard tank is 292 Imp. gal, and that of each inboard tank is 658 Imp. gal, making a total usable fuel capacity of 1,900 Imp. gal (2,282 U.S. gal). Two 145 gal slipper tanks are optional.

Cabin Air The whole of the fuselage, with the exception of the nose portion, and nosewheel bay and tail portion, is designed for pressurization to a differential pressure of 6.5 lb/sq in. Three Roots type cabin superchargers mounted on the engine-driven accessory gear boxes provide an air supply of approximately 75 lb/min at 25,000ft. The pressure control equipment is by AiResearch. Cabin sea level conditions can be maintained up to 15,000ft, and 8,000ft conditions up to 30,000ft. Cabin rate of climb is automatically limited. A safety valve is provided to blow off at 6.75 lb/sq in and a twin inward-relief valve is fitted.

De-icing Airframe thermal de-icing utilizes engine exhaust heated ram air ducted to the leading edges of the mainplanes, tailplane and fin. The windshield is de-iced by alcohol fluid. The propeller blades, spinners and engine and oil cooler air intakes are de-iced electrically by heating elements operating at 208v A.C.

Hydraulics The system provides power for raising and lowering the undercarriage, application of wheel brakes, and nosewheel steering. Hydraulic power is supplied by two Lockheed Mk 9 pumps driven by the two inboard engines. Operating pressure is 2,000-2,500 lb/sq in and either pump will provide sufficient power for the whole system.

Electrics The main electrical installation operates at 27½v D.C. derived from four 9kW generators, one driven by each engine. Three 24v 25 amp/hr batteries are provided to maintain electrical supply with engines off, and there is provision for a fourth battery when engine internal starting is required.

FLIGHT DECK The cockpit layout provides for a flight crew of two, but a supernumerary crew member can be accommodated if required in a jump seat folding flat on the floor when not in use.

PAYLOAD ACCOMMODATION Typical standard seating accommodation is 8 passengers four abreast in the forward cabin, and 44 passengers four abreast in the main cabin, a total of 52 passengers. In the 56-seat version, the area occupied by the aft-end wardrobes and freight compartment in the standard aircraft is utilized to provide a lounge with a wardrobe, this arrangement providing additional seating for four passengers in the lounge. International standard seat tracks are fitted. Two toilets with adjoining washrooms are provided between the two cabins in the line of the propellers. Two pantry buffets are provided at the rear of the main cabin.

A large main freighthold is provided under the cabin floor between the nosewheel bay and the wing leading edge, access being through two doors on the starboard side of the aircraft. Its gross volume is 250 cu ft. In addition, the standard aircraft has a freight compartment at the extreme aft end of the cabin of 120 cu ft gross, accessible through its own door on the starboard side of the aircraft. Spare stowage area (250 cu ft) is available in the vestibule opposite the passengers' entrance door. It is possible, subject to balance and structural considerations, to fill these three freight compartments respectively as follows: 3,725 lb, 2,140 lb, 550 lb.

COMMERCIAL HISTORY Originally the basic V.C.2 design, which owed its origin to Brabazon Committee recommendations, was much smaller than the present Viscount, weighing about 30,000 lb. That was in 1945. Early history of the type was uncertain, and in the summer of 1948 the Viscount seemed to be doomed. But at this point there began a process of increasing the power of the Roll-Royce Dart and stretching and increasing the weight of the airframe—measures which saved the aircraft. A fleet of 20 Viscount 701s was ordered by B.E.A. in 1950. The first production machines were delivered in early 1953 at a weight of 56,000 lb. Passenger capacity was 47, and the engines were Dart 505s of 1,400 s.h.p. The first commercial scheduled services were inaugurated in April 1953. Since 1954 power and weight went up, and today the latest Viscount 700Ds aircraft can operate at 63,000 lb. The Suffix "D" denotes the installation of the Dart 510 of 1,600 s.h.p.

During 1952 B.E.A. ordered the first of a new family of the then-called Viscount Majors, designated 800 Series. The fuselage of this series was stretched 46in ahead of the wing, and in addition the rear pressure bulkhead was moved back 65in, giving 111in of extra usable cabin length. The 800 was essentially a 700D with increased payload capacity for optimum economy on the shorter stages. B.E.A.'s fleet of 24 802s is now at full strength, having entered service in February 1957. Like the 700D, the 800 is powered by Dart 510s. Gross weight is 63,000 lb. Other operators of Viscount 800s are Aer Lingus, Transair, K.L.M. and in the near future N.Z.N.A.C. and Eagle.

From the 800 stemmed the higher-powered 806, sixteen of which B.E.A. are now taking delivery. This was an intermediate step to the Viscount 810/840 described in the preceding pages.

AIRLINERS OF THE WORLD

BOEING 707

Boeing Airplane Company, Seattle, Washington

FORTY years of aircraft manufacture, much of it devoted to pioneering the next step forward in transport design, forms the backdrop to the construction of Boeing's 707 jet transport—the aircraft that, perhaps more than any other, has come to be symptomatic of the "jet age."

Development of the KC-135s and the 707 prototype (the "Dash-80") has provided invaluable in-flight experience for the larger production versions of the 707 now under construction. Flight control systems, stability and control characteristics, systems engineering and structural integrity will all have been well-proven by the time the first 707 is delivered (to PanAm) in December 1958; the aircraft is due to be rolled-out this month prior to its first flight in December 1957.

The Boeing 707 is not one but a whole family of aeroplanes, each scaled up or down in size and power to meet the specific needs of various airlines. The "Dash-80" prototype is the smallest and lightest of them all, and is not truly representative of production 707s. The KC-135 is larger and heavier, and the airframe is much more nearly representative of the commercial 707. Offered now are a slightly confusing array of commercial 707s, having three different fuselage lengths, two sizes of wing, and three engine alternatives. The first version, for domestic use, is the 707-120, with Pratt and Whitney JT3C-6 (J57) engines of 12,500 lb thrust (without water injection). A second 120 version —as shown in the cutaway drawing—has a longer fuselage (144ft 4in instead of 134ft 6in) and a greater basic operational weight, but is otherwise similar. For example, both 120s have the same 2,433 sq ft ("small") wing.

The same basic airframe can be matched to the increased power of the Pratt and Whitney JT4A-3 (J75) engine, when it is designated the 707-220 (the "hot-rod," so called, as ordered by Braniff), or to 16,500 lb s.t. Rolls-Royce Conway 505 engines, when it becomes the 707-520. (So far, no 520s have been bought.)

The "Intercontinental," or overwater, Boeing 707s, intended for non-stop Atlantic operations, are altogether larger and heavier, with a larger, redesigned wing (2,892 sq ft) giving increased tankage, a maximum take-off weight of 295,000 lb (for taxying a gross weight of 296,000 lb is permitted), and the higher powers applied to the 220. Suffix variations to the 707 Intercontinental are indicative of the type of powerplant installed: thus the 707-320 is powered by JT4A-3s and the 707-420 by Conways. As with the 120 and 220 there is, in addition, a similar choice of two fuselage lengths; the shorter is dimensionally similar to the longer fuselage of the 707-120. All fuselages are 148in in diameter, 4in more than the KC-135.

BOEING 717

Originally known as the 707-020, the 717 is dimensionally similar to the short-fuselage 707-120. But operationally the aircraft are very different. The 717 has been designed to operate over short- and medium-length stages (200-1,500 miles), and the tankage has been drastically reduced from the 707 capacity to 8,403 gal.; the maximum range with full 130-passenger payload is now 2,400 miles. A painstaking engineering programme, including the reduction of some skin gauges and the use of lighter undercarriage forgings, has resulted in a corresponding reduction in structural weight, and the performance will hence probably be slightly better than that of the 707-120 with the same JT3 (J57) engines, although General Electric J79 engines are also contemplated. The take-off weight is 185,000 lb. This version was developed to compete with the Convair 880. The price—about $3.7 million—is some $500,000 less than the 707-120.

AIRFRAME The structure is largely conventional, and stress levels have been kept on the conservative side. Little use is made of spot-welding or (unlike the 707's DC-8 and Convair 880 competitors) of titanium, although integrally milled skins are widely used throughout the wing. Considerable use is made of crack stoppers and alternative load paths in what is essentially a fail-safe design.

Fuselage The fuselage is built in four sections. The first extends from the front pressure bulkhead to behind the forward entry door on the starboard side. The next and largest is a tubular section which terminates at the wing trailing edge; the third section (sub-contracted to Ryan) tapers back to the rear pressure bulkhead, and the final piece is the extreme tail, which is independent of the tail unit. Most of the structure is identical to that of the KC-135, although the upper bubble diameter has now been extended on all versions to 148in, 4in larger than the tanker. All the frames and stringers are of various riveted, angle or channel sections, and skin joints are made along strong longitudinal members reinforced with doubling strips. Much heavier frames are used at the wing spar stations; these are extrusions which are attached to the spars by forgings. At the intersection of the upper and lower bubble radii, transverse tie-booms form the basis of the conventional floor structure, except over the wing, where the floor is built as part of the wing structure. There are two main doors on the port side, opposed by slightly smaller service doors or emergency exits to starboard; all are of the plug type and are wider and deeper than their frames. The upper and lower edges of each door can be folded inwards and downwards on parallel linkages to reduce the effective depth, and the door, pivoting on the ends of hinged arms, can then slide out edgeways through its opening. Under-floor freight and service compartments are provided with doors on the starboard side only which push in and slide sideways on rails. An optional feature which several airlines have ordered is the provision of glass-fibre baggage containers which can be pre-loaded with about 1,500 lb of

AIRLINERS OF THE WORLD

BOEING 707 . . .

baggage each. Five of these fit into the forward baggage hold and are then slid into place by a mechanical loading device located within the fuselage. Rectangular section windows (9in by 12½in) are rather small, and are spaced with one in each 20-in frame. There are additional emergency exits above the wing between the frames flanking the 15th and 19th windows from the front.

Wing Each complete wing comprises three sections: a centre section of the same width as the fuselage, to which are bolted port and starboard main planes swept back at 35 deg. There are two widely spaced spars with an extruded T-form boom above and an angle below, with heavy sheet webs, stiffened by vertical stiffeners at and between each nose rib location. The rear spar is cranked just outboard of the outer nacelle, where it is swept back at an increased angle, but still converges with the front spar. From immediately outboard of the low-speed ailerons, the metal tip is detachable about a line perpendicular with the rear spar. Because the spars are so widely separated across the chord, there are many closely spaced ribs, the majority of which are unperforated heavy gauge assemblies at 90 deg to the rear spar with multiple riveted-angle vertical stiffeners. Similar ribs between the inboard nacelle and the wing joint are set at varying angles to the rear spar, so that at the root they become parallel with the aircraft's centre line.

Several of the inner ribs have large rectangular cut-outs spanned by vertical stiffening angles. The underside of the leading edge hinges for access to the tanks from the root to the break joint.

Integral tanks of considerable volume are formed by the top and bottom skins and the wing spars. Fuel is allowed to circulate through the spaces between the ribs and skin left by the depth of the stringers. Inspection doors of conventional type retained by screws and anchor-nut rings are set-in flush with the bottom skin.

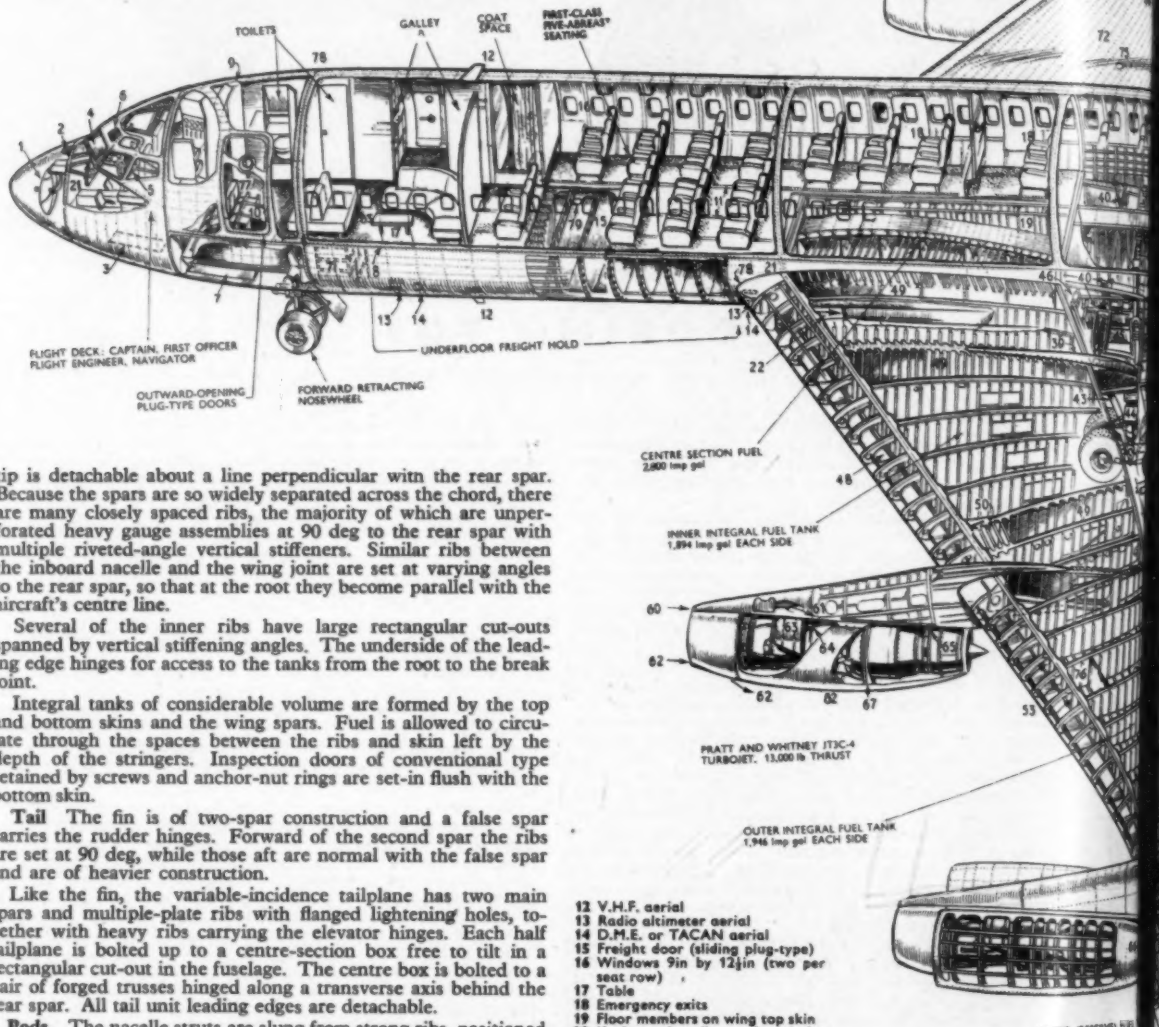
Tail The fin is of two-spar construction and a false spar carries the rudder hinges. Forward of the second spar the ribs are set at 90 deg, while those aft are normal with the false spar and are of heavier construction.

Like the fin, the variable-incidence tailplane has two main spars and multiple-plate ribs with flanged lightening holes, together with heavy ribs carrying the elevator hinges. Each half tailplane is bolted up to a centre-section box free to tilt in a rectangular cut-out in the fuselage. The centre box is bolted to a pair of forged trusses hinged along a transverse axis behind the rear spar. All tail unit leading edges are detachable.

Pods The nacelle struts are slung from strong ribs, positioned diagonally to those between the wing spars, but parallel with the line of flight. There is hence a cruciform joint formed with the inter-spar ribs carrying the outer flap tracks. A large forged anchor, providing root fittings for the two strut spars, is bolted to the front spar. Below this forging extends a strong frame, triangulated by a compression tube bolted to the underside of the fore and aft rib. Two substantial vertical chordwise members carry the powerplant. On the Pratt and Whitney JT3C there are mounting pick-ups on top of the compressor inter-spool section, which are attached to the front strut frame *via* a forged yoke and braced by a forged stay on each side. Forged attachments also pick up the top of the turbine support casing. "Structural fuses" are incorporated in the pylon attachment to prevent damage to the wing structure in the event of a belly landing.

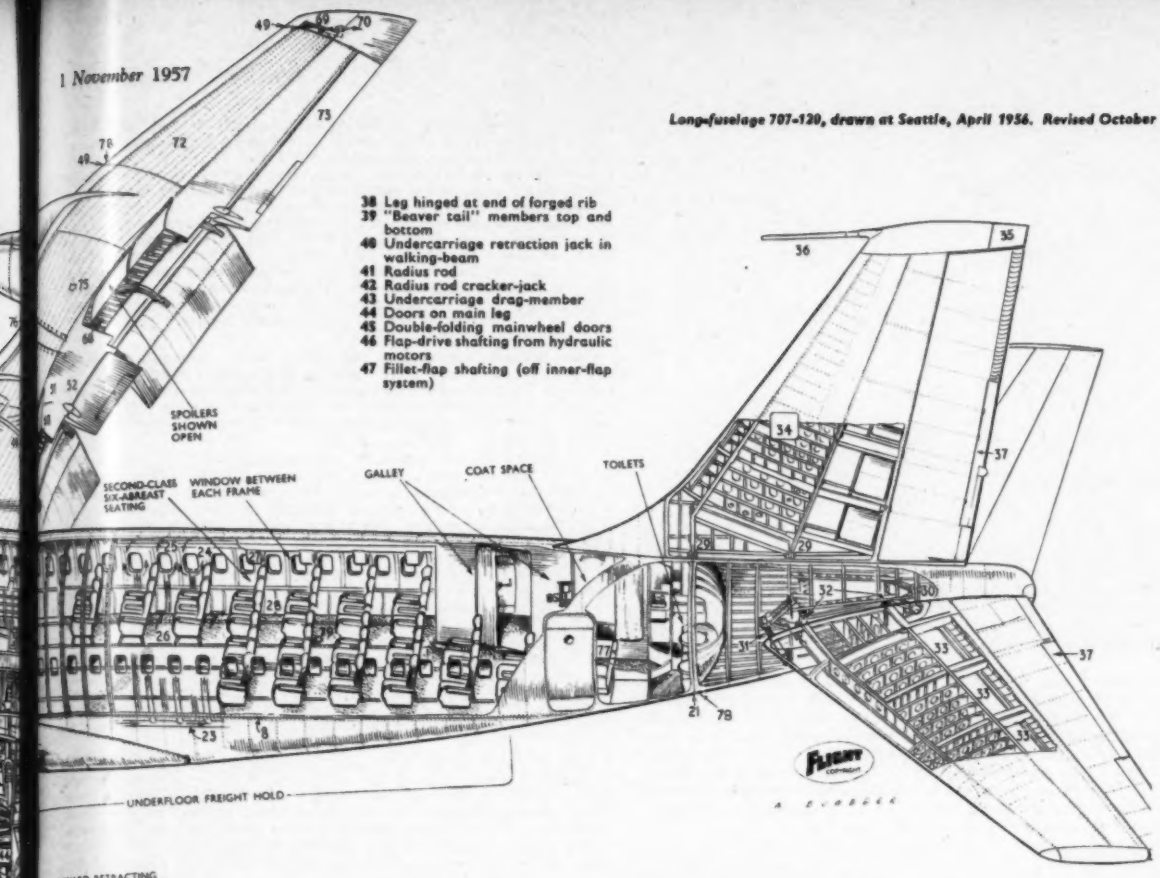
Undercarriage The main legs are hinged to massive trunnions

1 Cloud/collision radar scanner
2 Glide-slope aerial
3 Doppler aerial (true ground speed)
4 Nesa-glass windscreens
5 Direct-vision panel (slid to rear)
6 "Vision-in-a-turn" windows
7 Nosewheel doors shut with gear down
8 "Double bubble" intersection line
9 A.T.C. transponder aerial
10 Nosewheel box
11 Seat tracks (1in increment)

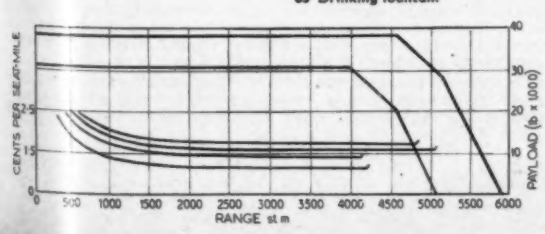

TOILETS
GALLEY
COAT SPACE
FIRST-CLASS FIVE-ABREAST SEATING
FLIGHT DECK: CAPTAIN, FIRST OFFICER FLIGHT ENGINEER, NAVIGATOR
OUTWARD-OPENING PLUG-TYPE DOORS
FORWARD RETRACTING NOSEWHEEL
UNDERFLOOR FREIGHT HOLD
CENTRE SECTION FUEL 2,800 Imp gal
INNER INTEGRAL FUEL TANK 1,894 Imp gal EACH SIDE
PRATT AND WHITNEY JT3C-4 TURBOJET. 13,000 lb THRUST
OUTER INTEGRAL FUEL TANK 1,946 Imp gal EACH SIDE
OUTER (RESERVE) FUEL 361 Imp gal EACH SIDE

12 V.H.F. aerial
13 Radio altimeter aerial
14 D.M.E. or TACAN aerial
15 Freight door (sliding plug-type)
16 Windows 9in by 12½in (two per seat row)
17 Table
18 Emergency exits
19 Floor members on wing top skin
20 Keel member (integral tank for engine water)
21 Pressure bulkheads
22 Intake to air-conditioning heat exchangers
23 Cabin-air distribution ducts
24 Air passing up between windows
25 Air delivery ducts under hat-racks
26 Air extraction at floor level
27 "Passenger service units"
28 "Hot-wall" panelling
29 Fin/fuselage joints
30 Pivot for variable-incidence tailplane
31 Tailplane screw-jack
32 Tailplane centre-section joints
33 Control-surface balance panels
34 V.O.R. aerial
35 Loran aerial
36 H.F. aerial
37 Control tabs

Long-fuselage 707-120, drawn at Seattle, April 1956. Revised October 1957.



38 Leg hinged at end of forged rib
39 "Beaver tail" members top and bottom
40 Undercarriage retraction jack in walking-beam
41 Radius rod
42 Radius rod cracker-jack
43 Undercarriage drag-member
44 Doors on main leg
45 Double-folding mainwheel doors
46 Flap-drive shafting from hydraulic motors
47 Fillet-flap shafting (off inner-flap system)
48 Leading-edge inspection panels
49 Fuel tank end-ribs
50 Fuel system dry-bay (shut-off valves, defuelling connections and pressure switches)
51 Bonded stiffeners in trailing-edge surfaces
52 Honeycomb sandwich in trailing-edge surfaces
53 Hot-air de-icing, double skin full length of leading edge
54 Spoiler operating jacks
55 Flap screw-jack
56 Flap tracks and rollers
57 Gust damper (70 m.p.h. limit)
58 Aileron/spoiler linkage
59 Low-speed aileron linkage
60 Intake to cabin-air turbo-compressor (engines 2, 3 and 4)
61 Outlet from turbo-compressor
62 Airflow through engine oil-coolers
63 Oil tank
64 Main engine mounting
65 Rear engine "steady"
66 Aluminium cowlings
67 Firewalls
68 Cove-lip door (covers gap when flaps up)
69 Fuel system surge-tank
70 N.A.C.A.-type inlet to tank vent system
71 Electrical racks (forced air cooled)
72 Two (independent) boost pumps in each main tank
73 Honeycomb-sandwich aileron skins
74 Typical wing section
75 Gravity fuel fillers
76 Pressure-refuelling dry bay
77 Cabin attendants' seats
78 Production break-lines
79 Wide-angle lens for freight-hold inspection
80 Tank access doors
81 Spring tab (full surface movement available for ground test)
82 Sundstrand-driven 40 kVA A.C. generators on engines 2, 3 and 4
83 Eight-seat lounge
84 Dividing screen (1st class forward, tourist aft)
85 Drinking fountain



BOEING 707-120

Four Pratt and Whitney JT3C-6 of 12,000 lb sea level static thrust each (dry)

Dimensions: Span, 130ft 10in; length overall, 134ft 6in ("short body"), or 144ft 4in ("long body"); height, 38ft 7in; gross wing area, 2,433 sq ft; track) 22ft 1in; wheelbase, 52ft 4in; max. fuselage cross-section, 170.5in high by 148in wide; tailplane span, 39ft 8in; distance from centre-line to engines, 27ft 2in (inners), 46ft 1in (outers).

Weights: Empty, about 109,700 lb on —120; max. landing weight, 175,000 lb; design gross weight, 248,000 lb (taxi condition); payload, 41,800 lb; equivalent i.s.w.l., 52,140 lb (I.C.A.O. method).

Performance: Take-off field length (long-range cruise with 200 n.m. alternate plus two hr reserve at 15,000ft, I.S.A. no wind), 5,900ft for 1,500 n.m. stage, 7,780ft for 2,500 n.m. and 10,500ft for 3,500 n.m.; normal cruising speed, 591 m.p.h.; landing field length, 6,420ft.

BOEING 707-220

Four Pratt and Whitney JT4A-3 of 15,500 lb sea level static thrust each (dry)

Dimensions: Span, 130ft 10in; length overall, 134ft 6in; height, 38ft 3in; gross wing area, 2,433 sq ft; track 22ft 1in; wheelbase 52ft 4in; max. fuselage cross-section, 170.5in high by 148in wide; tailplane span, 39ft 8in; distance from centre-line to engines, 27ft 2in (inners), 46ft 1in (outers).

Weights: Empty, 111,700 lb; max. landing weight, 175,000 lb; max. gross weight, 248,000 lb; payload, 33,800 lb.

Performance: Field lengths, shorter than —120; normal maximum cruising speed, 608 m.p.h.

BOEING 707-320

Four Pratt and Whitney JT4A-3 of 15,500 lb sea level static thrust each (dry)

Dimensions: Span, 142ft 5in; overall length, 144ft 4in; height, 38ft 8in; gross wing area, 2,892 sq ft; track, 22ft 1in; wheelbase, 55ft 8in; tailplane span, 45ft 8in; distance from centre-line to engines, 33ft (inners), 51ft 11¼in (outers).

Weights: Empty, "over 120,000 lb"; max. landing, 195,000 lb; zero fuel weight, 177,500 lb; max. take-off weight, 295,000 lb (296,000 lb for taxying); payload, 38,000 lb.

Performance: Take-off field length (assumptions as for 707-120), 5,550ft for 1,720 st. m. stage, 6,850 for 2,900 st. m. and 8,550ft for 4,000 st. m.; normal cruising speed, 600 m.p.h.; landing field length, 6,400ft.

BOEING 707-420

Four Rolls-Royce Conway 505 of 16,500 lb sea level static thrust each

Dimensions: As for 707-320.

Weights: Manufacturer's empty weight, 121,468 lb; operating empty weight, 128,314 lb; max. landing weight, 195,000 lb; zero fuel weight, 177,500 lb; max. take-off weight, 295,000 lb (296,000 lb for taxying); payload, 38,000 lb.

Performance: Take-off field length, max. T.O. weight, 9,000ft; cruising speed at 200,000 lb at 30,000ft, 585 m.p.h.; landing field length at 190,000 lb, 6,280ft.

BOEING 717

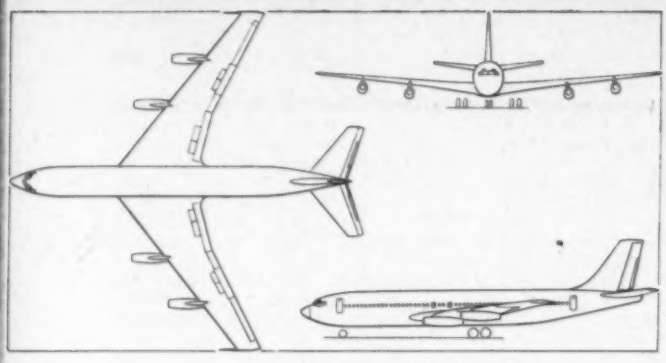
Four Pratt and Whitney JT3C-6 of 12,000 lb sea level static thrust each (dry)

Dimensions: As for 707-120.

Weights: Design payload, 32,500 lb; gross weight, "from 185,000 lb."

Performance: Range with maximum payload, 1,700 st. m.; range with full passenger payload (130 tourists), 2,400 st. m.; C.A.R. field length, max. weight, 5,400ft; landing field length (at 150,000 lb), 5,500ft.

Payload-range and cost curves for the JT3- and JT4-engined 707-120 and 707-320. Assumptions for payload-range are: allowances for take-off, climb and acceleration (no credit for descent); still air, N.A.C.A. standard day; fuel reserves 17,000 lb (320) and 16,000 lb (120). Costs are to 1955 A.T.A. method (with no cargo, 7 yr depreciation, 750 hr engine overhaul, and 1½ hr fuel reserve), still air, long-range cruise technique, full passenger payload, standard day. From top to bottom: 320 (131 seats), 420 (131 seats), 220 (124 seats), 120 (124 seats).



General arrangement of the 707-120.

AIRLINERS OF THE WORLD

BOEING 707 . . .

held against the rear spar of the wing box between forged fore and aft members (known as "beaver-tails") which lie along the top and bottom surfaces of the wing and are through-bolted to a strong rib. Each beaver-tail projects from the line of the skin and tapers out to a position mid-way between the wing spars; the lower pair are in tension and the upper in compression, and undercarriage loads are transmitted through them into the wing box.

The main legs are retracted inwards by a hydraulic jack mounted in a walking beam hinged to a link anchored to the edge of the fuselage floor. The legs are braced by radius rods which are hinged nutcracker fashion and broken by *ad hoc* jacks picking up on the deep fuselage keel-web. Tyre pressures vary from 128 lb/sq in to 145 lb/sq in, depending upon the design weight. The nose gear retracts forwards and is steered by twin cylinders to give a turning radius of 21ft about the inner bogies. All wheel doors are closed by individual jacks.

POWERPLANT The standard engine on the 707-120 is the Pratt and Whitney JT3C-6 turbojet which, in production models, will have a dry rating of 12,000 lb (13,400 lb wet). This is a commercial variant of the well-developed J57, with tandem compressors, a can-annular combustion system and with most of the accessories grouped under the casing of the rear high-pressure compressor. Oil is contained in a 5.75-gal saddle tank above the front low-pressure compressor casing, and is cooled in tubular coolers low on each side of the nacelle. Approximately 350 gal of water will be carried for water injection on all full-load take-offs at ambient temperatures over about 50 deg F.

Power for the -220 and the -320 will be provided by Pratt and Whitney JT4A-3s, the commercial version of the J75, developing a sea level I.S.A. static thrust of 15,500 lb (dry). The nacelle configuration will be similar to the JT3C, but will weigh at least 2,000 lb more. The Boeing 717 will be powered (with dry-rated engines) by the same powerplant as the 120. Other versions of the 707, the 420 and the 520, will be powered by Rolls-Royce Conway 505s with a take-off static thrust at sea level I.S.A. of 16,500 lb thrust.

SYSTEMS **Flying Controls** Some 4,242 wind-tunnel hours devoted to development of Boeing jet transport designs, and flight experience with the B-47 and B-52, have enabled the Boeing Airplane Company to develop an almost completely manual system for the 707 which—on the prototype—has proved very satisfactory at all speeds. All the flying controls are sealed by a novel arrangement of internally pressure-balanced panels. Broadly, these consist of inter-rib sections of flat plates, hinged to chordal extensions from the leading edge of the moving surfaces, and arranged to move with the surface inside balanced-chamber boxes formed by the skins and ribs. The fixed structure of the wing behind the rear spar, for instance, is made rigid enough to form accurate housings for these panels. The upper fixed skins are stabilized by spanwise-bonded channels, and the lower skins are honeycomb-filled sandwiches, better able to withstand the intense high-frequency buffet from the engines.

The elevators are used in conjunction with a trimming tailplane operated by an electric screw-jack with a manual standby, and the rudder is a simple surface with anti-balance tab and trim tabs actuated by cables incorporating automatic tension-regulating units. On versions with JT4 and Conway engines, the rudder will be power-boosted below 200 kt.

The lateral control system is unconventional and of considerable interest. Inboard and outboard ailerons and hydraulically actuated spoilers, which function as speed brakes, are provided. At low speeds, the outboard ailerons—operated manually by tabs—come into use when the flaps are lowered, but at high speeds these are locked out of action, and lateral control is effected by the inboard ailerons and the spoilers. The former are relatively small surfaces interspaced between the flaps, moved manually by spring tabs and provided with gust dampers for speeds up to 70 kt. The spoilers are permanently linked to the aileron circuit, and can be flicked open to act as speed brakes. Used differentially, they provide the aircraft with a high rate of roll. (The Dash-80 has in fact been rolled.)

The main flaps are of the double-slotted type; the outer flap sections are driven through screw-jacks and torque tubes, geared to a hydraulic motor mounted on the centre section rear spar, and the inner portions are similarly driven from an independent system which operates small split "fillet flaps" at the trailing edge roots. Emergency actuation is electric.

Fuel Apart from the 4,460 Imp. gal centre-section tank, all tankage is integral. Outwards along the span of the wing are a 1,894 Imp. gal tank between the root rib and a point inboard of the inner pod strut; a dry bay immediately inboard of the strut; a 1,946 Imp. gal tank from inboard of the inner strut to a point inboard of the outer strut; and a reserve tank of 361 Imp. gal capacity from inboard of the outer strut to the outer end of the low-speed aileron. From this point outboard to the tip is a further tank. Pressure refuelling sockets are provided beneath the wing and gravity fillers above the wing tanks. Electric pumps can rapidly dump the centre-section fuel in the event of an emergency. Pressure switches for de-fuelling connections are provided in the inner dry bay, and shut-off valves operate automatically if the bottom of a nacelle gets rubbed off. The tanks are vented through the spanwise stringer channels.

Air Conditioning Turbo-compressor sets driven by air bled from the first spool of the engines draws fresh air from a ram intake immediately above the main engine air intake. This is ducted along the face of the front spar to the centre-section, where it turns aft and passes to a primary heat exchanger served by ram intakes at the forward end of the belly fairings over the mainwheel bays. The cabin air can then pass either direct to distribution manifolds or by way of an air cycle cooling unit, secondary heat exchanger and water separator. The secondary heat exchanger is fed from a bifurcation on the belly intake; its air is dumped overboard immediately forward of the rear spar and a vacuum ground-cooling connection is provided at the same point.

De-icing Hot air is extracted from the delivery of the high-pressure spool of the JT3C at about 700 deg F and ducted along the leading edge of the wing. A further supply of bleed air is passed around the engine intakes. Electric heater mats are fitted on the leading edge of the tailplane, and Nesa glass is fitted in the forward-facing panels of the cockpit canopy.

Hydraulics A pump on each engine supplies hydraulic fluid at 3,000 lb/sq in to the flaps, undercarriage, spoilers, wheel brakes and nosewheel steering. Centralized hydraulic panels are provided in the main undercarriage bays.

Electrics A 30 kVA alternator is mounted on each engine coupled to a Sundstrand constant-speed drive. All power is AC and is generated at 115 V, three-phase, 400 c/s, and the four alternators can be paralleled or, in the event of a malfunction, can serve specific loads individually. These include the fuel booster pumps, standby hydraulics and flap motors.

The first production Boeing 707-120, for PanAm, takes shape in the Seattle plant. Roll-out was imminent at the time of writing, and first flight is due next month. Delivery of PanAm's fleet will begin in December 1958.

PAYLOAD ACCOMMODATION As with most of the world's air transports, there is no standard seating arrangement for the 707, and the manufacturers have made provision for variations in layout to be made as quickly as possible. There are, for example, no fixed bulkheads throughout the length of the cabin, although portable partitions, incorporating coat stowage, can be installed in the seat rails recessed into the cabin floor.

In the short-fuselage versions of the Boeing 707, big wing and small wing, the normal first-class accommodation is 106, five abreast, and in the all-tourist version, with mainly six-abreast seating, 129. A typical mixed-class version would seat 30 first-class passengers and 78 tourist, with a dividing portion between them. Capacities of the under-floor freight-hold are 490 cu ft forward and 800 cu ft aft.

The long-fuselage Boeing 707 will accommodate 124 first-class passengers, 150 in a tourist version and 34 first-class and 90 tourist-class in a mixed-class version. The under-floor freight capacity is 1,600 cu ft.

AIRLINERS
OF THE WORLD

DOUGLAS DC-8

Douglas Aircraft Company
Santa Monica, California

THE name of Douglas has something of a legendary ring in the air transport world; stage by stage, as their DC-series has developed, the company has succeeded in coming out with the right design at the right time—and always on time. Their reputation for being commercially right is owed to a great deal of very hard and shrewd thinking—and accurate guessing—some years before a new design ever appears, with all the variables weighed in the balance to see if an advantage is offered on each.

The DC-8 has been considered as a commercial aircraft from the start, and it is probably true to say that the sales success that Douglas have achieved, without a parallel military programme or the construction of a prototype, is the direct result of their reputation. When the DC-8 (known originally as the Model 1881) was first announced, and orders placed by U.S. domestic operators, it weighed a maximum of 257,000 lb, had a span of just over 134ft, was 140ft 6in long and was powered by four Pratt and Whitney JT3 turbojets. But in widening its operational scope, the weight crept up, and by 1956 two versions were being offered, one of which was designed for long-range operation and had a heavier gauge structure in the wing, horizontal tail, aft fuselage and landing gear. The span was increased to 139ft 8in, length to 150ft 6in, and the weight to 287,000 lb. Four powerplants, with thrusts ranging from 12,500 to 20,000 lb, are now offered.

AIRFRAME The structure has been designed to attain the highest possible degree of structural safety with stress levels generally no higher than those in the DC-7. Previous experience with the DC-6 and 7 series has been brought to bear in designing the upper "bubble" of the DC-8 fuselage, which is characteristically similar to the piston-engined hull, although on a larger scale. Apart from particular emphasis on the elimination of stress concentrations, and the utilization of smooth tapering, the possibility of eventual fatigue failures (particularly as the result of local damage) has been recognized, and the structural philosophy has been to incorporate rip-stop characteristics to prevent the dangerous propagation of cracks. This concept involves divided peripheral reinforcing members throughout the pressure cabin, and very extensive research has resulted in the evolution of advanced bolting and riveting techniques.

Fuselage Deep channel frames spaced at 20in pitch carry riveted Z-section stringers and doublers to provide multiple load paths in certain regions. The fuselage skin is 14 s.w.g. or lighter section; much research has been devoted to lap-jointing of the panels, and this is effected through multiple runs of countersunk rivets on heavy channel sections with a sandwich doubler plate (with pressed stiffening joggles) acting almost as a second skin.

The cross-section is formed from two diameters, the upper being the greater, and meeting along a slight cusp (the upper radius is 73.5in; the lower radius 68.7in). A characteristic of Douglas design is that the full radius is reached as soon as possible after the flight deck, a fact which will facilitate future stretching. The untapered tubular section is almost 100ft long.

The ventral keel between the two main undercarriage bays is formed by a single girder 5ft deep, and is crossed by transverse beams tied to each frame, which form the main structural members of the floor. The light alloy upper panels are reinforced by plastic longitudinals of top-hat section. All doors above the floor are outward-opening plug-type structures, fitted with double hinge-axes, so that they can be pulled inwards and then slid out edgeways. The lower, cargo doors are mounted on track rollers and slide upwards and inwards. A considerable amount of titanium (330 lb) is used throughout the fuselage; in rip-stoppers above and below the floor line in the forward fuselage, and below the floor line on frames in the ventral part of the pressurized structure. Titanium is used for the door jamb doublers of the entire forward service door, the aft main entrance door, all four lower cargo compartment doors, and the upper halves of the forward main entrance door and the aft service door. Titanium forgings of 15 lb weight are used in various places in the structure.

Windows contain three layers of Plexiglas or Gafite; the two pressure-bearing outer sheets form a sandwich with hot, dry air, and the thin, flat inner lining has an anacoustic sound-absorbing function, although it can take the full dP with a factor of three. The windows are spaced on alternate frames at 40-in intervals and are of an unusual profile approaching the optimum form, the sides being arcs of large radius with a smaller radius in the corners. They are 16in high and 14in wide at the major and minor axes. Stiff sloping frames in the rear fuselage transmit loads from the three spars in the fin. The profile of the rear fuselage has been so chosen as to prevent the occurrence of awkward shock waves near the tail surface by minimizing local airflow accelerations. Three strong frames are provided to pick up on the wing spars and utilize forgings around part of their periphery. The extreme nose is formed by a large dielectric moulding for the search radar.

Wing Typical of the fail-safe policy that has been adopted throughout the structure is the three-spar construction of the wing. All spars have modified T-section booms with heavy sheet webs carrying vertical stiffeners. The centre and rear spars run parallel; the latter runs out to the tip and carries the ailerons; whereas the former is terminated where it intersects the front spar outboard of the outer engines. Each wing is made as a complete unit joined together at the aircraft centre-line with a heavy butt-strap. Well outboard on each half-wing is a manufacturing break which is intended to remain undisturbed after completion of the aircraft. Inboard of this break the upper and lower skins forming the two-cell box (massive pieces of roll-tapered light alloy 46ft 3in by 10ft 4in a quarter-inch thick at the root tapered-out to 0.129in at the outer extremity), are double curved over the dihedral break. Forged strips reinforce the spar booms at the kink caused by the start of sweep at each root. Roughly three-quarters of the wing loads are accommodated by the skin and underlying stringers. The profiles of the latter were evolved by the N.A.C.A. and are extrusions. Under the top compression skin they are of Y-form and are riveted to brackets on the ribs. The under-surface stringers are of modified I-section with the wider flange abutting the skin and are more closely spaced than those on the upper surface. Since the space between the front and rear spars forms a large integral tank, the ribs are liberally provided with cut-outs and act as tank baffles, but they are also separated from the skin by the depth of the stringers.

The use of advanced aerodynamic data enabled Douglas to achieve a limiting Mach number of 0.95 for a given weight with a wing sweep of 30 deg, five deg less than the original project.

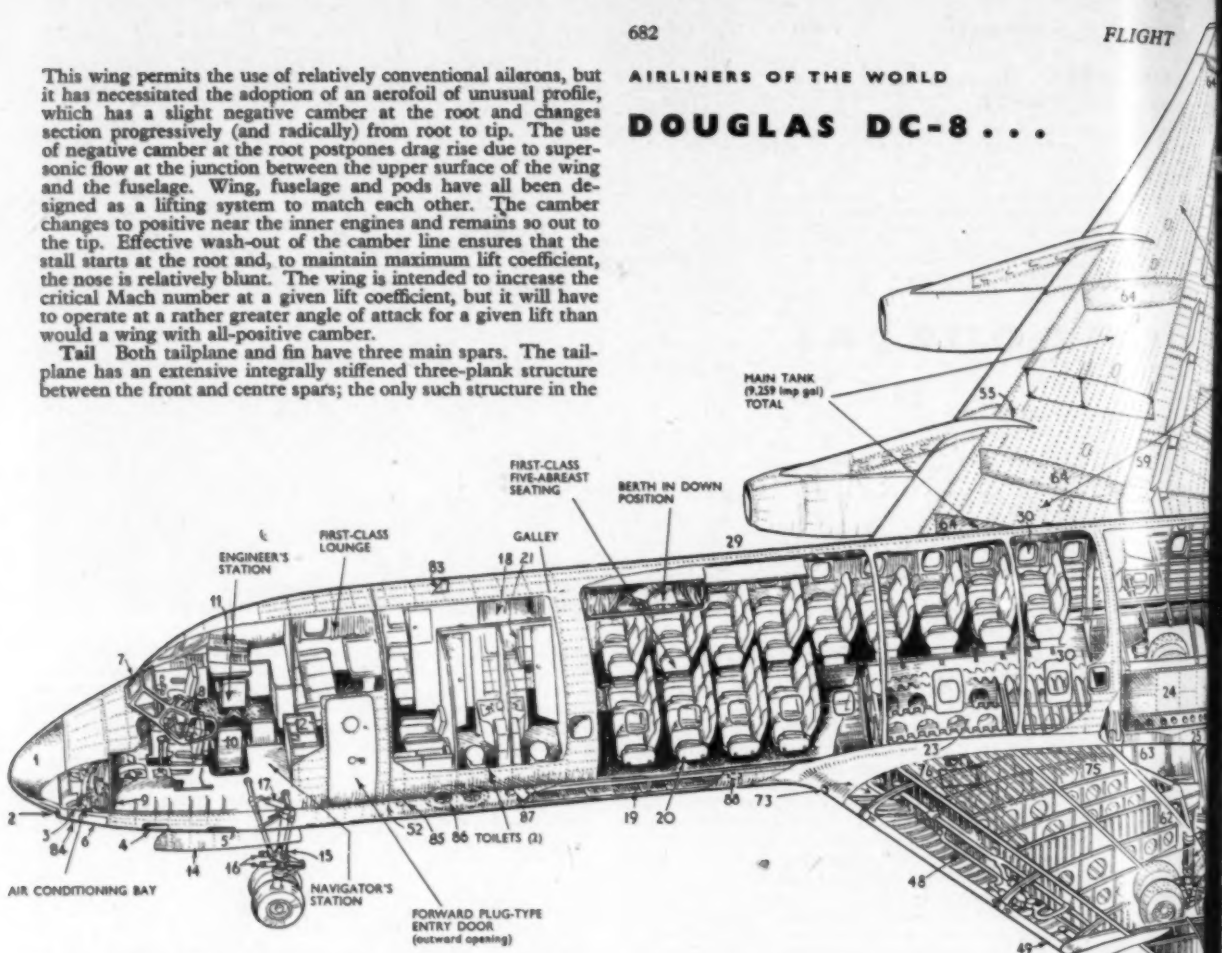
DOUGLAS DC-8 . . .

This wing permits the use of relatively conventional ailerons, but it has necessitated the adoption of an aerofoil of unusual profile, which has a slight negative camber at the root and changes section progressively (and radically) from root to tip. The use of negative camber at the root postpones drag rise due to supersonic flow at the junction between the upper surface of the wing and the fuselage. Wing, fuselage and pods have all been designed as a lifting system to match each other. The camber changes to positive near the inner engines and remains so out to the tip. Effective wash-out of the camber line ensures that the stall starts at the root and, to maintain maximum lift coefficient, the nose is relatively blunt. The wing is intended to increase the critical Mach number at a given lift coefficient, but it will have to operate at a rather greater angle of attack for a given lift than would a wing with all-positive camber.

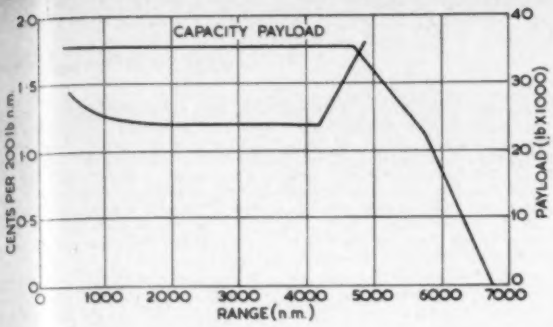
Tail Both tailplane and fin have three main spars. The tailplane has an extensive integrally stiffened three-plank structure between the front and centre spars; the only such structure in the whole airframe. Each plank has three stiffened angles, and the two leading members are tapered off by the front spar. Most of the remaining skin in the tail unit is stabilized in a bonded inner section with stiffened flutes. The fin and rudder structure terminates no less than 8ft from the tip and the whole remaining surface is tuned for use as an aerial with a central feeder cable. Above the light alloy structure, glassfibre sections are inserted extending over the entire chord of each surface and continuing up and down the rudder trailing edge. The remainder of the metal structure is then bolted to the glassfibre spars and around the profile periphery.

Pods The pods are interesting in that their trailing edges are curved inboard to follow the natural streamlines of the airflow; this gives lower drag than pylons used as fences which constrain the air to flow axially across the wings. The complete pylon and nacelle assembly is sub-contracted to Ryan. The engine pylons have two spars, chordwise frames and stringers. The spars pick up on stiff ribs in the wing which (unlike the majority of the ribs, which are perpendicular to the rear spar) run fore and aft. The nacelles are conventional double-skinned assemblies in which the entire access doors (amounting to virtually half the nacelle and hinged along the junction with the pod) are of titanium sheet. A wide strip of the trailing edge of the pylon is also fabricated from titanium.

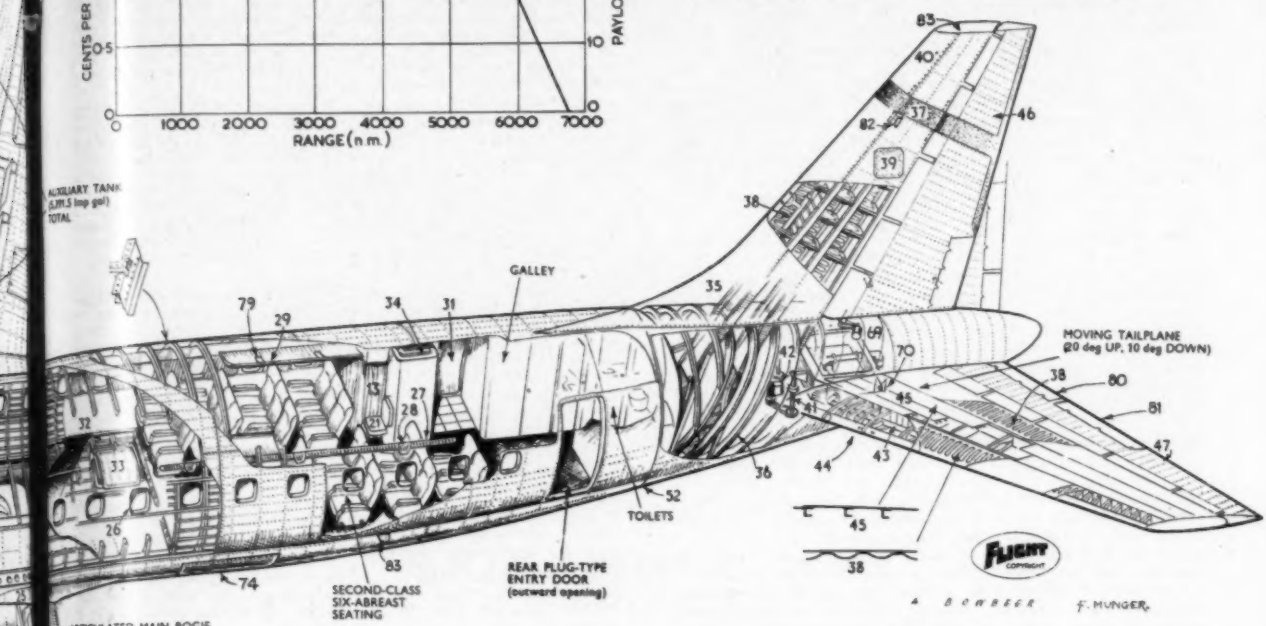
Undercarriage The main gear consists of a conventional shock strut carrying a tandem bogie on which the rear wheels are articulated to allow the aircraft to pivot about a point 4.5ft from the inside gear. The track is 20ft 9½in. Each main leg is a forging, forked at the upper end and carried by a large triangulated forging bolted to the aft face of the rear spar and to a pair of sub-spars. The main legs are held fixed in the down position by a set of side brace links which are locked on-centre by a pair of spring-loaded toggle links. The wheels are automatically braked during the first part of the retraction cycle and the gear is closed by three doors in the latched-up position. The largest of these, covering the wheels, is operated by a hydraulic jack controlled by the position of the gear; the door is closed when the wheels are down. Goodyear dimpled tyres at 131 lb/sq in and disc brakes are fitted. All undercarriage units can be unlocked and allowed to fall under gravity.

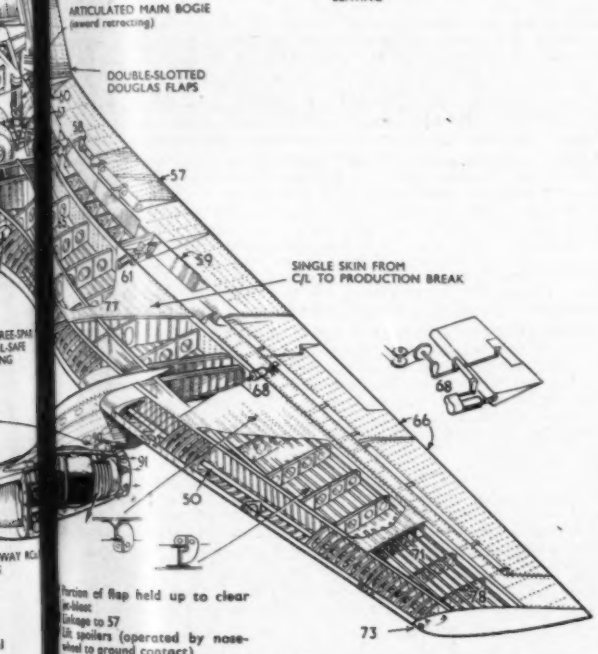


1 Weather radar dielectric radome
2 Intake to cabin air system
3 Cabin-air turbo-compressors (55,000 r.p.m.)
4 Turbine exhaust
5 Heat exchanger exhaust
6 Access door
7 Electrically-heated multi-layer glass screen (no wipers)
8 Upper windows each side
9 Forward pressure bulkhead
10 Supernumerary seat
11 Engineers' panel
12 Radio racks (air cooled)
13 Coats
14 Twin nosewheel doors
15 Nose gear geometry similar to DC-7
16 Steering cylinders (10 deg each way with rudder, 78 deg by handwheel)
17 Retraction jack
18 Galley service door
19 Underfloor hold (door starboard)
20 Wall-fixed slots
21 Attendant's seat
22 Centre-joint butt-strap
23 Centre section tank ("overwater" model 1910 only)
24 Centre keel-member (5ft deep)
25 Mainwheel doors (normally closed after undercarriage extension)
26 Windows (18½in x 15in)
27 Grille (cabin air in: out at floor level)
28 Passenger-address speaker
29 Hat racks
30 Emergency exits
31 Emergency doors
32 "Hot wall" panelling
33 Inward-opening freight door
34 Concealed lighting
35 Integral three-spar fin
36 Sloping frames
37 Fibreglass (dielectric) structural isolation
38 Bonded inner skin
39 V.O.R. aerial
40 H.F. aerials (1 and 2)
41 Tailplane screw-jacks
42 Tailplane hydraulic and electric motors
43 Tail de-icing trunk
44 Retractable bumper
45 Integrally-stiffened skin
46 Fully-powered rudder
47 Manual elevators
48 Fuel system runs
49 De-icing duct (cyclic heat)
50 De-icing trunk
51 Hot air anti-icing
52 Production break
53 Primary (combustion) airflow
54 By-pass airflow (diagram)
55 Inswept pylon tails
56 Intake to Sundstrand-drive oil-coolers



Payload-range for the Conway DC-8 at 287,500 lb (132 passengers), with reserves for 260 n.m. diversion at 30,000ft plus 1 hr holding at 15,000ft, warm-up, taxying, take-off and manoeuvre. Costs are based on the revised 1955 A.T.A. method. Approximate price: $6m.





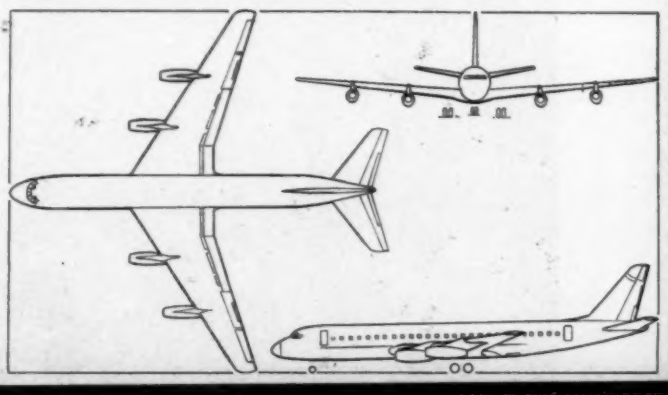
Portion of flap held up to clear re-blast
Linkage to 57
Lift spoilers (operated by nose-wheel to ground contact)
Multiple scissor-links (inner to outer flap)
Flap-operating linkage
Main-leg subframe
Main-leg retraction jack
Tank bay end-rib (full depth)
Unnotched ribs (no full depth)
Divided, powered, ailerons (inner =high speed, outer=low speed)
Bonded trailing-edge structure
Aileron power unit (emergency manual tab)
Rudder power-unit
Tailplane hinge axis
Tank for injection water (JT-3 engine only)
Fire-suppression bottles (378 cu in C.B. and Freon)
Leading-edge venting
Air brakes
Skin thickness 0.250in

76 Skin thickness 0.190in
77 Skin thickness 0.156in
78 Upper skin 0.064in, lower 0.063in
79 Passenger service panels (position variable with seat pitch)
80 Control tab
81 Geared tab
82 H.F. Antenna coupler and lighting arrester
83 V.H.F. aerials (three)
84 Glide-slope aerial
85 D.M.E. aerial
86 A.D.F. aerials
87 A.T.C. transponder
88 Radio altimeter aerial
89 A.D.F. sense aerials (four)
90 Rolls-Royce thrust-reversal units
91 Rolls-Royce noise suppression nozzles

DOUGLAS DC-8

Dimensions (all versions): span, 139ft 9in; length, 150ft 6in; overall height, 42ft 4in; wing area, 2,758 sq ft; sweepback at ¼ chord, 30 deg; volume of both lower cargo compartments, 1,415 cu ft.

	Domestic JT3C-6	Domestic JT4A-3	Intercontinental JT4A-3	Intercontinental Conway
Weights:				
Gross weight (lb) ...	265,000	265,000	287,500	287,500
Max. usable T.O. weight (lb)	264,400	265,000	287,500	287,500
Landing weight (lb) ...	189,000	189,000	190,500	190,500
Manufacturer's weight empty (lb)	115,839	118,265	120,737	117,423
Operating weight empty (lb)	121,034	123,532	128,862	125,272
Zero fuel weight (lb) ...	161,200	165,000	167,550	163,750
Freight (lb)	14,150	14,150	14,150	14,150
Space limited capacity payload (lb) first-class	33,620	33,620		
Space limited capacity payload (lb) mixed-class			35,930	35,930
Space limited capacity payload (lb) tourist ...	37,910	37,910	37,910	37,910
Performance:				
Level flight speed at max. cruise thrust T.A.S. (m.p.h.) 30,000ft. ...	561	586	586	590
C.A.A. T.O. field length (ft)	9,860	7,300	8,760	8,870
C.A.A. landing field length (ft)	6,680	6,630	6,690	6,690
Range with 6,500ft T.O. field length, first-class version (st. m.) ...	2,040	3,470		
Range with 6,500ft T.O. field length, mixed-class version (st. m.)...			3,070	3,330
Range with 6,500ft T.O. field length, tourist version (st. m.) ...	1,790	3,220	2,950	3,210
Range, first-class (st. m.)	3,940	4,060		
Range, mixed-class (st. m.)			4,490	4,850
Range, tourist-class (st. m.)	3,680	3,790	4,360	4,670



AIRLINERS OF THE WORLD

DOUGLAS DC-8 . . .

The nose leg is essentially a scaled-up DC-7C unit arranged for twin wheels. It is equipped with two steering cylinders capable of scrubbing the nose tyres up to maximum gross weight. Steering is by rudder pedals up to 10 deg either side of centre, and by cockpit wheel for ±78 degrees thereafter. The rear swivel-mounted truck of the main gear can be unlocked for taxying when the nosewheel has been turned 40 deg either side of centre. The nose gear retracts forwards into an unpressurized box and is latched up in a similar manner to the DC-6. Mechanically-linked doors close the aperture during the final 10 per cent of the retraction cycle.

POWERPLANTS The domestic DC-8 is powered with either Pratt and Whitney JT3C-6 engines with a wet rating (for production aircraft) of 13,400 lb thrust, or by Pratt and Whitney JT4A-3s (commercial J75s) rated 15,500 lb dry. The DC-8 Intercontinental version is powered by either JT4A-3s or by Rolls-Royce Conway 507s (RCo.10) with a thrust of some 16,500 lb at sea level, I.S.A. Three hundred and fifty gal of water (no methanol) are carried for use during full-load take-offs in temperatures of more than about 50 deg F. A 10-kVA drive is provided for a water pump for each engine, and it is arranged that to avoid icing difficulties, no water will remain after two minutes' operation. Water is carried in the wing-tips and centre-section. Accessories on the Pratt and Whitney engines are mounted beneath the high-pressure compressor casing. Two drum-type oil coolers are provided, each fed with air from individual ram intakes in the lower part of the nacelle. No auxiliary intake will be provided for British engines as a fuel/oil heat exchanger will be employed. Two-shot Ficon systems are supplied for fire suppression, and the nacelle can be isolated.

Douglas have pursued an independent line of development on the problems of noise suppression and are experimenting with a combined noise suppressor and thrust reverser that is hydraulically operated and consists of clam-shell doors that fold flat into the nacelle, but are linked to join the after-ends together to deflect the jet efflux in the open position.

SYSTEMS **Flying Controls** Without the opportunity for an in-flight test programme of a representative aircraft at an early stage in the design of the DC-8, Douglas opted for fully powered systems on the ailerons and rudder, a variable-incidence tailplane operated hydraulically and servo-tab elevators. Artificial feel is employed. The ailerons are split into inner and outer portions, the inners driving the outers at low air speeds through a torsion-bar spring, so that all the portions function in unison. Above a limiting I.A.S. the air loads react against the spring to uncouple the outer sections. The rudder and aileron power units are identical except in size, and each includes a spring-tab locking linkage and spring-loaded cylinder which normally holds the tab neutral, but allows automatic manual reversion if hydraulic pressure falls. The loads in this condition are said to be no higher than on some current piston-engined transports. The elevators incorporate aerodynamic tabs and the tailplane is operated by a chain-driven two-start Acme screw through 2 deg up to 10 deg down from a hydraulic motor. An electric standby is used for autopilot drive. Four small wing spoilers—long narrow plates along the upper surface—are provided for use during landing and are not operable in flight; they are cable-linked and can be extended hydraulically after touch-down to increase the weight on the nosewheel.

Double-slotted, single spar flaps of Douglas design are employed, the short inner portion on each wing being joined to the outer portions by multiple mechanical links. Generally, the geometry is similar to that of the DC-7C, actuation being hydraulic by two rams on each flap and one on each inner section. A portion of flap in the line of each inner engine is hinged to a mechanical linkage so that it remains horizontal as the flaps come down and does not enter the jet stream. Under the belly are two large rectangular air brakes.

Air conditioning Cabin air is bled from the compressor of each engine and cooled to 400 deg F. It is then passed through four turbo-compressors, any one of which is capable of maintaining full cabin pressure. The dP is 8.77 lb/sq in (6,700ft at 40,000ft) and any one turbo-compressor can maintain it. Behind the nose undercarriage bay a closed-circuit Freon refrigeration system supplied by the Carrier Corporation is installed. Warm air is fed into trunks in the cabin roof, and into the wall, where it acts as a source of radiant heat. The air finally enters the cabin beneath the baggage racks. Overboard spill from the cabin and air turbines is ejected through a propelling nozzle on the ventral centre line. The hot air supply is also fed into rain removal air blasts on the windscreen and blow-away jets for clearing the runway beneath the engine of debris.

Fuel The wing integral tank is terminated at the inner end by the central line of the aircraft on the Intercontinental DC-8, and by an end-rib on domestic versions. The outer end-rib is spaced about three ribs from the wing tip and the manufacturing joint divides the capacity into what are termed main and auxiliary tanks. The total capacity is 14,650 Imp. gal and 18,000 Imp gal in the Intercontinental aircraft. Each engine has its own fuel and tank system interconnected by a cross-feed manifold, and an engine-driven fuel-booster pump is installed on each engine in addition to an electric tank-mounted pump. Underwing refuelling sockets are provided, through which the system can be pressure-refuelled in 16 minutes.

Hydraulics The system is powered by two engine-driven variable-displacement pumps at a pressure of 3,000 p.s.i. and operating on Skydrol 500. Hydraulic services include the undercarriage, flaps, spoilers, speed brakes, wheel brakes, nosewheel steering, engine starting air compressor, tailplane trim, and flying controls. Emergency power comes from an electric pump.

Electrics Early in the life of the DC-8 it was decided to adopt a 115/208 V three-phase 400 c/s AC system with an alternator installed on each engine and four 25 amp transformer/rectifier units to standard DC requirements. The alternator is driven by a Sundstrand drive.

De-icing All the aerodynamic surfaces of the nacelle pylon are de-iced thermally, with hot air bled from the engines. The double-skinned leading edges are fed with air from multiple-branch manifolds which exhaust into a curved diaphragm behind each leading edge. The air then escapes into the space forward of the front spar on each surface and thence to atmosphere.

FLIGHT EQUIPMENT The normal operating crew consists of a captain, first officer and "systems manager," and there is a seat for a supernumerary. The Intercontinental DC-8 has provision for a navigator.

Among the comprehensive radio equipment is search radar, housed in a heated nose radome. Most aerials are suppressed, the fin (previously described) incorporating V.O.R. windows in structural dielectric, and the whole upper part of the vertical tail is isolated to form an aerial of the correct impedance and radiation pattern. Standard equipment includes duplicated H.F. and V.H.F. communication, duplicated A.D.F. and glide slope, marker beacon, Loran, radar transponder, radio altimeter, together with flight inter-phone and public address system.

Payload Accommodation Seats and partitions are mounted on standard rails, reading lights and cold-air outlets are readily changeable, and passenger and service doors and buffets are at each end of the fuselage, so that a wide variety of interior layouts is possible. Typical layouts provide 118 to 122 seats in the first-class layout, 132 in a mixed-class and 144 tourist. Even in this configuration, the seats are pitched 40in, and coincide with the spacing of the windows. The maximum number of passengers that can be carried in a high-density arrangement is 171. Freight and baggage holds are under the floor and provide a total cargo weight of 14,150 lb, in a total cargo volume of 1,415 cu ft.

COMMERCIAL HISTORY The first DC-8 order was placed by PanAm, who bought 25 in October 1955 at a price of about £57 m. Later, this order was revised so that four aircraft (with JT4A engines) would go to Panagra early in 1960, and 21 to PanAm in December 1959. Subsequent orders have been as follows (totalling 122):—

United, October 1955, 18 with JT4 and 12 with JT3 (for subsequent re-engining) for delivery from May 1959 at £62.5 m; National, November 1955, 6 with JT3 from mid-1959 at £13.2 m; K.L.M., November 1955, 8 with JT4A (option on further 4) from March 1960 at over £18 m; Eastern, 18 JT4s, March 1960 (option on another 8 with JT4 from autumn 1961) at a total (with option) of £59 m with spares; Japan Air Lines, December 1955, 4 with JT4A from September 1960 at £9.8 m; S.A.S., December 1955, 7 with JT4A from 1960 at £18 m; Swissair, January 1956, 3 with JT4A from spring 1960 at £8.74 m; Delta, 2 JT4 and 6 with JT3 from June 1, 1959, at £12.9 m; T.C.A., May 1956, 6 with Rolls-Royce Conway from early 1960; and U.A.T., 3 with JT4 from 1960; T.A.I., 2 from 1960 and Olympic, 2 from 1960.

Progress with the wing structure and United Air Lines personnel inspecting the fuselage before the units were joined last month.

AIRLINERS OF THE WORLD

BRITANNIA 310

Bristol Aircraft Ltd. Filton, Bristol

THE Britannia was conceived by Bristol in 1948, in the belief that propeller-turbine power would provide the world's air transport business with the most economical application of turbine propulsion. Through all the fast-moving events of the intervening decade Bristol have not deviated from this belief. The Britannia stands out today as the champion of a cause to which more and more financially hard-pressed airlines are becoming devotees—the cause of economy rather than of speed. The Britannia is the expression of Bristol's belief that though a place exists for both jet and turboprop propulsion, it is the latter which offers the cheapest—and hence the most competitive—kind of long-range travel. The Britannia is, in effect, an attempt by aircraft designers to give the users and operators of air transport the full benefit of economy first and foremost.

Whether this philosophy proves to be idealistic in the face of competition from the big jets no one can yet say: but there are signs in every section of the airline business of financial as well as technical second-thoughts in the big jet re-equipment programmes. If present trends in narrowing profit margins continue (and the introduction of thrift-class fares is unlikely to reverse this trend), there will be doubts about the financing of these big jet programmes, and a new emphasis on low-operating-cost equipment may become apparent. It is possible, too, that pressures may be brought to bear within the airline industry to bring about the differential pricing of jet and turboprop travel: if this comes to pass, the Britannia is in a unique position so far as the long-haul market is concerned. It is significant that in the past few months both Douglas and Lockheed have been giving great thought to turboprop conversions of their long-haul piston transports, indicating that American manufacturers, too, have sensed a changing climate of opinion within the operating industry.

The future demand for any type of aircraft must be a matter for speculation, but it is fair to say that the Britannia 310, being basically a design for economy, is in a strong position in an increasingly cost-conscious market.

AIRFRAME A measure of the structural efficiency achieved in the Britannia is the fact that structure weight is barely one-quarter of gross weight, despite the low nominal stress level and the heavy fatigue-resistant properties of the design.

The basic airframe material is high-strength light alloy. The 12ft diameter fuselage is stressed for a differential cabin pressure of 8.3 lb/sq in, and general skin thickness is 18-gauge. The fuselage is of constant circular section for 49ft 2½in of its 124ft 3in overall length (this is a 10ft 3in increase on the early Britannia 100), and there are no bulkheads or other structural intrusions anywhere in the usable part of the fuselage. The floor is carried on longitudinal beams, and is designed for an overall loading of 75 lb/sq ft between the wings and the toilets, and 37 lb/sq ft elsewhere. The two under-floor freight-holds are stressed to 75 lb/sq ft.

There are four emergency exit doors at the aft end of the cabin, including the main entry door, plus two jettisonable window-hatches in the cabin over the wing. The windows comprise two separate glazings which can be removed independently, and both of which are capable of standing full pressure.

A heavy programme of static and fatigue-testing involving five separate fuselage specimens has been carried out by Bristol and at the R.A.E., Farnborough.

The wing has a taper box-spar bounded by webs at 15 and 50 per cent chord. Bending loads are taken by upper and lower skins and spanwise stringers. Overall skin thickness is 0.16in; general stress levels are low and special attention has been paid to detail design from the point of view of fatigue. The interspar box provides the maximum possible space for fuel.

The flaps are in four sections, and are disposed between the inner nacelles and the fuselage and between the inner nacelles and the ailerons. Each flap-section is double-slotted and is extended on curved steel tracks by screw-jacks (driven in unison through torque tubes from an electric actuator). Ailerons are of conventional construction, and hinged freely to the wing (see Flying Controls).

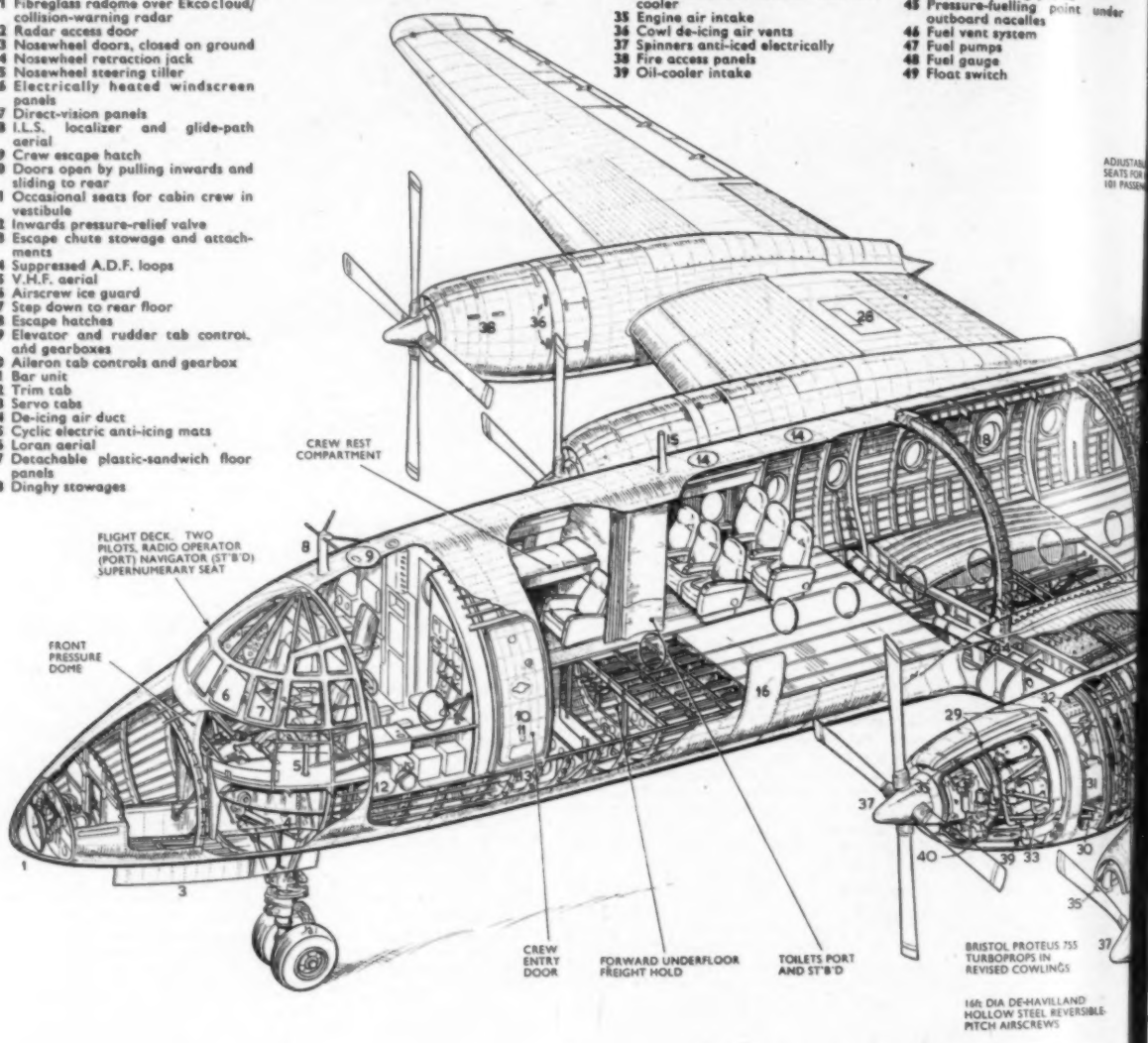
The undercarriage is of British Messier design and make. The main legs each carry a four-wheel bogie, the rear wheels of which have rather greater track than the front pair. Tyre pressure is 139 lb/sq in, and wheels, tyres, brakes and anti-skid units are by Dunlop. The bogie retracts into a nacelle bay covered by three pairs of doors; upon retraction the bogie-beam pivots about a lateral axis until it is in line with the leg, whereupon the entire unit retracts rearwards, the bogie being finally stowed in an inverted position. The nose undercarriage has twin wheels splined to a live axle, and is steerable hydraulically through a range of 50 deg on either side of neutral; the unit retracts forwards.

POWERPLANT The Britannia has four Bristol Proteus 755 turboprops of 4,120 e.h.p. each (B.O.A.C.'s Britannia 102s have Proteus 705s rated at 3,900 e.h.p.) driving de Havilland four-blade hollow-steel-blade propellers. The cowling has, in effect, three skins; the entire engine is enclosed within a double-walled cowling, between the skins of which passes the intake air, while the innermost skin is a light unstressed fairing clipped to the engine itself. The top cowling panel is located between a pair of fixed longitudinal beams and can be lifted off after releasing its fasteners. The remainder of the cowling is formed by two large panels, port and starboard, which hinge upwards to provide unobstructed access to the engine and oil cooler. Exhaust gas passes through a stainless-steel jet pipe running back across the top of the wing, to which it is attached by two pairs of pivoted links; the jet exhausts from a propelling nozzle above the trailing edge. The

AIRLINERS OF THE WORLD

BRITANNIA . . .

1 Fibreglass radome over Ekcocloud/collision-warning radar
2 Radar access door
3 Nosewheel doors, closed on ground
4 Nosewheel retraction jack
5 Nosewheel steering tiller
6 Electrically heated windscreen panels
7 Direct-vision panels
8 I.L.S. localizer and glide-path aerial
9 Crew escape hatch
10 Doors open by pulling inwards and sliding to rear
11 Occasional seats for cabin crew in vestibule
12 Inwards pressure-relief valve
13 Escape chute stowage and attachments
14 Suppressed A.D.F. loops
15 V.H.F. aerial
16 Airscrew ice guard
17 Step down to rear floor
18 Escape hatches
19 Elevator and rudder tab control and gearboxes
20 Aileron tab controls and gearbox
21 Bar unit
22 Trim tab
23 Servo tabs
24 De-icing air duct
25 Cyclic electric anti-icing mats
26 Loran aerial
27 Detachable plastic-sandwich floor panels
28 Dinghy stowages
29 Firewalls
30 Tubular engine mountings
31 Oil tank
32 De-icing heat exchanger
33 Compressor tappings to cabin-air and de-icing systems
34 Air-conditioning cold-air unit and cooler
35 Engine air intake
36 Cowl de-icing air vents
37 Spinners anti-iced electrically
38 Fire access panels
39 Oil-cooler intake
40 One 50 kVA alternator on each engine (auxiliaries driven electrically)
41 Tailpipes and shrouds
42 Icing inspection light
43 Flap-operating screw-jacks
44 Gravity-fuelling points
45 Pressure-fuelling point under outboard nacelles
46 Fuel vent system
47 Fuel pumps
48 Fuel gauge
49 Float switch

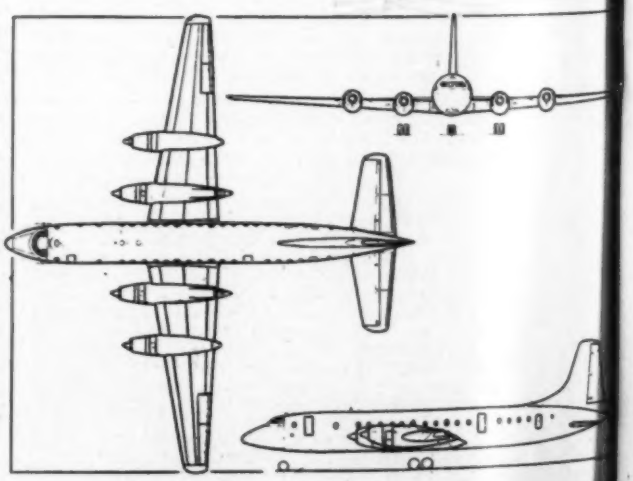

CREW REST COMPARTMENT
FLIGHT DECK. TWO PILOTS, RADIO OPERATOR (PORT) NAVIGATOR (ST'B'D) SUPERNUMERARY SEAT
FRONT PRESSURE DOME
CREW ENTRY DOOR
FORWARD UNDERFLOOR FREIGHT HOLD
TOILETS PORT AND ST'B'D
BRISTOL PROTEUS 755 TURBOPROPS IN REVISED COWLINGS
16ft DIA DE HAVILLAND HOLLOW STEEL REVERSIBLE-PITCH AIRSCREWS

jet pipe shroud is of titanium, as also are other appropriate hot portions of the installation. The engine is slung from four twin mountings around a ring in line with the centrifugal compressor. Each engine has a reverse-flow axial compressor followed by a centrifugal impeller.

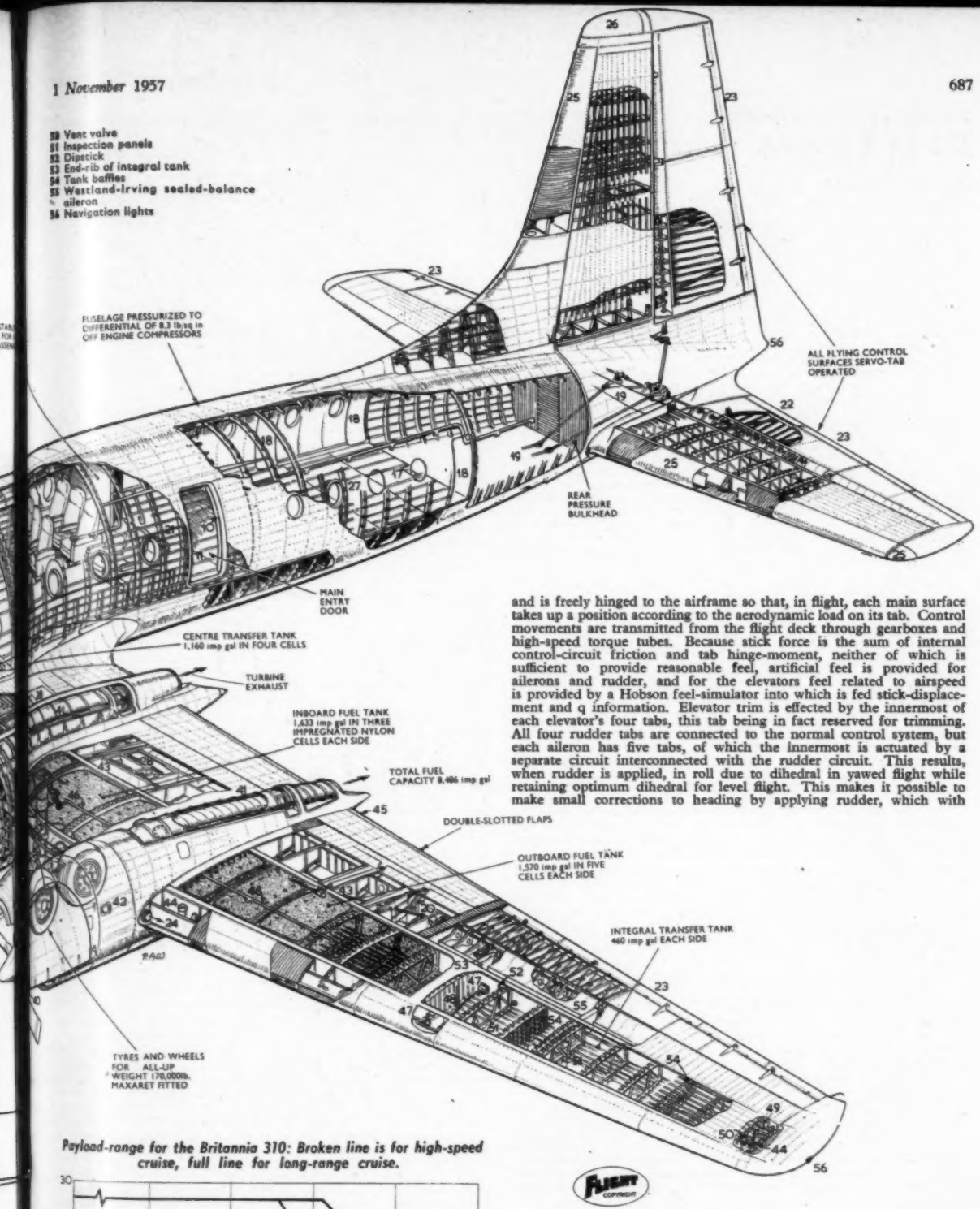
The airscrews are advanced units of de Havilland design and manufacture, incorporating the well-known Hamilton Hydromatic principle of operation. They are fully feathering and reversing, and incorporate the D.H. hydraulic pitch lock, a safety device which locks the blades at the angle at which they are operating in the event of any failure in the hydraulic control system. Phase and r.p.m. synchronization equipment are standard. A super-fine ground pitch-setting permits the engines to be opened up to high r.p.m. on the ground for running the generators.

The Bristol B.E.25 Orion turboprop, which develops some 75 per cent more cruising power, will be available for retrospective installation in 1960. (B.O.A.C. have an option on 60 Orions.)

SYSTEMS **Flying Controls** The primary controls of the Britannia are not in any sense power operated; the basic principle of operation takes the form of aerodynamic servo tabs operated directly from the cockpit. Each surface carries full-span tab-sections on its trailing edge

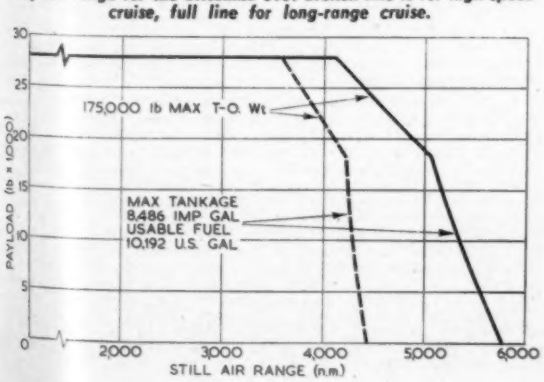


50 Vent valve
51 Inspection panels
52 Dipstick
53 End-rib of integral tank
54 Tank baffles
55 Westland-Irving sealed-balance aileron
56 Navigation lights


FUSELAGE PRESSURIZED TO DIFFERENTIAL OF 8.3 lb/sq in OFF ENGINE COMPRESSORS
ALL FLYING CONTROL SURFACES SERVO-TAB OPERATED
REAR PRESSURE BULKHEAD
MAIN ENTRY DOOR
CENTRE TRANSFER TANK 1,160 imp gal IN FOUR CELLS
TURBINE EXHAUST
INBOARD FUEL TANK 1,633 imp gal IN THREE IMPREGNATED NYLON CELLS EACH SIDE
TOTAL FUEL CAPACITY 8,486 imp gal
DOUBLE-SLOTTED FLAPS
OUTBOARD FUEL TANK 1,570 imp gal IN FIVE CELLS EACH SIDE
INTEGRAL TRANSFER TANK 460 imp gal EACH SIDE
TYRES AND WHEELS FOR ALL-UP WEIGHT 170,000lb. MAXARET FITTED

and is freely hinged to the airframe so that, in flight, each main surface takes up a position according to the aerodynamic load on its tab. Control movements are transmitted from the flight deck through gearboxes and high-speed torque tubes. Because stick force is the sum of internal control-circuit friction and tab hinge-moment, neither of which is sufficient to provide reasonable feel, artificial feel is provided for ailerons and rudder, and for the elevators feel related to airspeed is provided by a Hobson feel-simulator into which is fed stick-displacement and q information. Elevator trim is effected by the innermost of each elevator's four tabs, this tab being in fact reserved for trimming. All four rudder tabs are connected to the normal control system, but each aileron has five tabs, of which the innermost is actuated by a separate circuit interconnected with the rudder circuit. This results, when rudder is applied, in roll due to dihedral in yawed flight while retaining optimum dihedral for level flight. This makes it possible to make small corrections to heading by applying rudder, which with

Payload-range for the Britannia 310: Broken line is for high-speed cruise, full line for long-range cruise.



BRISTOL BRITANNIA 310

Four Bristol Proteus 755 of 4,120 e.h.p.

Dimensions: Span, 142ft 3½in; length, 124ft 3in; height on ground, 36ft 8.3in; gross wing area, 2,075 sq ft; total pressurized volume, 9,375 cu ft; total usable volume above floor, excluding flight deck, 5,877 cu ft; undercarriage track, 31ft.

Weights: Maximum take-off weight, 175,000 lb; max. landing weight, 129,000 lb; zero fuel weight, 122,000 lb; operating weight empty, 87,695 lb; manufacturer's weight empty, 82,537 lb; capacity payload, 28,000 lb.

Performance: Balanced field length, standard conditions, 7,000ft; landing distance from 50ft, standard conditions, 129,000 lb, 3,330ft; range-payload performance, see graph; cruising speed (mean), 391 m.p.h. T.A.S.; cruising altitude, "cruise-climb" to 31,000ft.

AIRLINERS OF THE WORLD

BRITANNIA . . .

conventional controls would cause yaw with sideslip.

Special provision for control-locking is made; this is achieved by small hydraulic jacks, it being impossible when they are applied to open the throttles all at once above flight-idling power (one engine on each side can however be opened up to full power). Autopilot is the Smiths S.E.P.2.

Cabin Air Air is tapped from the centrifugal (h-p.) impeller of each Proteus engine, its temperature being reduced by ram-air heat exchanges. The circuit includes a Godfrey cold air turbine-expansion unit for further cooling. The maximum differential cabin pressure is 8.3 lb/sq in (6,000ft at 30,000ft), and two engines are capable of maintaining this pressure. At the latter altitude the fuselage is ventilated with 120 lb of conditioned air per minute, distributed from ceiling ducts. Air is taken away from the cabin through floor-level grilles and filters to jet pumps, which induce a re-circulation flow of 150 lb per minute. Air from the toilets, freight holds and pantry is dumped directly overboard. Normalair and Teddington Controls equipment ensure, respectively, automatic pressure and temperature control.

Electrics Auxiliary power is supplied by four 50 kVA Rotax alternators, one driven by each engine. Carbon-pile voltage-regulation is used in the main system, magnetic amplifiers being employed to control inverter frequency and voltage. Six 24-volt, 25 amp-hr lead-acid batteries comprise the storage capacity, and they are capable of supplying essential loads for 20 min in the event of complete generation failure; they can also provide two engine starts. Full electrical load can be maintained by any three alternators, and essential services, plus some domestic load, can be maintained by only two.

Hydraulics The Britannia's four hydraulic pumps are electrically driven; they are British Messier units, and are installed in the unpressurized portion of the fuselage. Pressure is maintained at 3,500 to 4,000 lb/sq in, and the hydraulic system powers undercarriage retraction, control-surface locking, and nosewheel steering. Wheel brakes take 1,750 lb/sq in; elevator artificial feel and control damping is a separate circuit. Accumulators maintain pressure for towing and parking purposes, and an independent pump supplies pressure for emergency undercarriage lowering. A separate electro-hydraulic system operates the Dunlop windscreen wipers.

Fuel All fuel is housed within the box spar of the wing. Capacity is made up of bag tanks (7,566 Imp. gal total) and integral tanks in the outboard wings (920 Imp. gal total). Total fuel capacity is thus 8,486 Imp. gal. Feed is by a pair of submerged booster pumps in each of the four main tanks; the low-pressure feed from each tank to its adjacent engine is independent of the others except for cross-feed, and any engine can be fed from any tank. Unusable fuel is less than 50 gal, and all but 1,600 gal can be jettisoned. The whole system is suitable for kerosine or JP-4, and heaters (using compressor air) are provided at the engine filters. Pressure refuelling at 150 gal/min is effected through connectors in the outer nacelles.

Ice Protection There are two major systems: hot air and electric mats. The former utilizes hot gas tapped from between the compressor- and power-turbines of each engine, diluted with air induced from the flow inside the cowling. This mixture is used to heat the leading edge and outer walls of the main cowling and intakes, together with the elbow to the compressor intake and the radial intake vanes. Pre-selected temperature control is automatic. Protection of the wings is also achieved by hot air from the same source.

The complete empennage is protected by Napier Spraymats applied to the leading edges of the tailplane and fin, and on the double-curvature surfaces of the elevator horn balances. They are applied also to the ventilating air intakes in the two upper fixed beams in each engine cowling. Airscrew blades and spinners are heated by internal electric elements. The six forward windscreen panels are also electrically heated by a transparent conducting layer on the outer glass lamination.

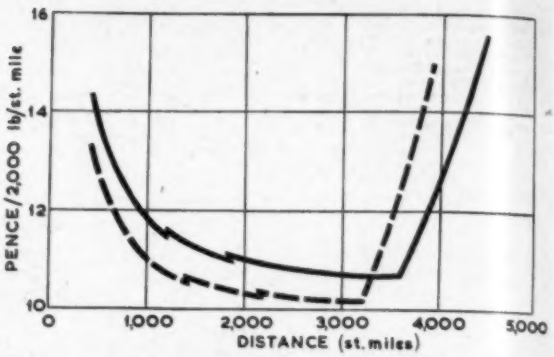
FLIGHT DECK Provision is made for two pilots, navigator and radio officer, with a supernumerary seat available for a fifth crew member. All essential instruments and controls can be reached by either pilot. The Smiths flight director system is fitted as standard, employing no more than two panel instruments—director horizon and beam compass. Each pilot's flight instrument panel conforms to the standard accepted layout, and the two large central panels are occupied by engine instruments. The centre portion of the roof contains radio controls, and roof windows on either side are of particular assistance when flying in the circuit.

The "systems" control panels are worthy of special note: the fuel panel, for example, is virtually a diagrammatic picture of the fuel system. All fuel lines are indicated, warning lights are in their correct relative positions and flow meters take the place of the engines. Similar panels are employed for other systems.

The navigator has a large chart table and access to the roof sextant, and all crew members are provided with generous stowage space for documents, personal effects, and so forth. Crew sleeping-berths (two bunks) may be fitted as required on the starboard side immediately aft of the flight deck.

Radio and Radar A typical installation is as follows: duplicated H.F. transmitter-receivers, twin V.H.F. transmitter-receivers; twin A.D.F. receivers; I.L.S.; D.M.E. (200 Mc/s); duplicated V.O.R.; Loran; search radar; intercom and public address systems.

Wherever possible, all aerials are suppressed. The forward part of the fin tip is the Loran receiver and the H.F. aerials are suppressed in each wing-root leading edge. Twin A.D.F. suppressed loops are submerged in the fuselage upper skin and the search radar is contained beneath the radome in the unpressurized portion of the nose. The latter part of the aircraft also carries V.O.R./D.M.E. homing aerials on either side and a D.M.E. distance aerial below.



Operating cost (S.B.A.C. method). Broken line, high speed cruise, full line, long range cruise. Approximate basic price: £1.25 m.

PAYLOAD ACCOMMODATION The Britannia's cabin is 99ft long and 12ft wide, and the entire length is unobstructed, with a headroom of 6ft 8in. Seat attachments are provided by two sets of twin slotted-rails set at the international standard track of 31.7in, and these slots are at 1in pitch to permit rapid changes of seating accommodation either four, five or six abreast. Movable partitions further permit variation of accommodation, and are designed to be installed quickly. Six-abreast seating for 93 passengers forms the standard version of the Britannia; this may be compared with the luxury first-class sleeper version, suitable for transatlantic non-stop services, which seats 64, including 17 single-width upper berths and 15 double-width lower berths with four fully reclining "sleeperette" chairs. The 17 upper sleeping berths are arranged to fold up into the roof; the lower berths are formed by the ingenious folding of passenger seats.

A crew rest-room may be installed in the forward cabin and an attractive cocktail-bar-lounge may be fitted aft as required. Five toilets are available in each version, two opposite and in line with the airscrew discs and the other three right aft. Adequate adjoining washroom facilities are provided. The 76-seat mixed-class arrangement allows for 60 tourist-class passengers in the main cabin and 16 first-class seats in the aft cabin, including the cocktail lounge. A spacious pantry is situated behind the flight deck.

Two underfloor freight holds, one forward of the wing (386 cu ft), the other aft (443 cu ft), are accessible *via* larger (30in by 51in) freight doors under the starboard side. Both freight holds are pressurized, and their floors stressed to 75 lb/sq ft.

COMMERCIAL HISTORY The first order for the Britannia was placed by B.O.A.C. in July 1949, for 25 aircraft. The first six of these were to have had Bristol Centaurus piston engines, but in December 1950 this idea was abandoned, and it was decided that all the aircraft should be powered by the Bristol Proteus turboprop. In August 1955 B.O.A.C. increased their order from 25 to 33 aircraft, made up as follows: 15 Britannia 102s, eight Britannia 302s, and ten Britannia 300LRs (since designated 312). Towards the end of that year the Corporation sold one of its 300-series aircraft to the Ministry of Supply, and ordered one more long-range Britannia 312. Five of the 302s, it was decided last year, would be brought up to long-range standard by installing full 312 wing tankage; their designation became 305.

Then, in December 1956, B.O.A.C. released these five 305s to Northeast Airlines of Boston, U.S.A. The aircraft were well advanced on the "second-source" Britannia production line of Short Brothers and Harland, Ltd., Belfast (set up in 1954), and Northeast saw in these aircraft an opportunity to get early delivery of a competitive airliner for use on their newly awarded route linking New York and Boston with Miami.

In September, when it became clear that production delays—largely brought about by American airworthiness requirements—would not permit delivery in time for Northeast's Christmas 1957 season, the U.S. airline postponed delivery. The five 305 aircraft may now be remodified and retaken up by B.O.A.C.; delivery will be possible in January and February of next year, permitting a more rapid build-up of the Corporation's long-range Britannia fleet.

B.O.A.C.'s medium-range fleet of 15 Britannia 102s entered service on February 1, 1957, and is now operating on the Corporation's routes to the Far East and Australia, and to East, Central and South Africa. The first half-year of operation was not free of the operational teething troubles from which new aircraft are prone to suffer: the problem of Proteus engine icing—only discovered during proving flights in Africa on April 3, 1956—proved to be particularly difficult to solve. B.O.A.C. and El Al (the Britannia's first export customer) took delivery of their first 310-series aircraft in September, duly certificated, and expect to start transatlantic services early in the New Year. Deliveries to other Britannia customers are now current, against an order book (including three M.o.S. 250s and 13 R.A.F. 250s) which is as follows: 102 series, B.O.A.C. 15; 250 series, R.A.F. Transport Command 13, M.o.S. 3; 300 series, M.o.S. 1, B.O.A.C. 5 (January-February 1958), Aeronaves de Mexico 2 (late 1957); 310 series, B.O.A.C. 18 (current), El Al 3 (current), C.P.A.L. 6 (November 1957-January 1958), Hunting-Clan 2, Cubana 2 (late 1958).

AIRLINERS OF THE WORLD

VANGUARD

Vickers-Armstrongs (Aircraft) Ltd., Weybridge, Surrey

NEARLY five years of close consideration by Vickers of a successor to the Viscount, culminating in two years of detailed discussion between the firm and B.E.A., led to the Corporation drawing up a specification in the early part of 1955. Prior to the issue of this specification—which ran to 50 pages and was probably the most detailed requirement ever given to a manufacturer by an operator—Vickers had studied about 60 different configurations for the new aircraft, including several with the high wing at one time favoured by B.E.A. The layout finally selected incorporated Rolls-Royce Tyne engines, and both airframe and powerplant have since developed together.

The basis of B.E.A.'s specification was for an aircraft that, with the special characteristic of an exceptionally large underfloor freight hold capable of accepting two-thirds of the maximum payload at normal densities, would cater for the very seasonal nature of its routes. A profitable volume of low density freight can be carried when passenger loads are normal, and at off-peak periods the Vanguard can be utilized primarily as a freighter without any conversion. There are other accrued advantages in freight handling, reduced turn-round time and the large working space available for access to systems. Vickers have estimated that a conventional "tube" layout would have cruised only 5 m.p.h. faster and weighed about 1,000 lb less.

Since 1954, the design has also been developed to suit American requirements (typified by T.C.A.), an all-freight version study has been made and the take-off weight has been increased to allow the maximum payload to be carried over stage lengths of up to 2,600 st m. A similar development process with the Tyne has stemmed from Rolls-Royce.

AIRFRAME Vickers have employed in the Vanguard a combination of safe-life and fail-safe philosophies, long fatigue life in primary components being combined with multiple load paths throughout. Stresses in the pressurized cabin skins have been kept to a maximum of about 12,000 lb/sq in and a safety factor of three is employed for the pressurization case. The wing box structure consists of three shear webs; in the event of failure of one, the remainder can deal with the loads. Single heat-treated alloy has been employed for predominantly tension members to obtain better ductility and reduce the likelihood of crack propagation. Fatigue meters will be installed on each aircraft.

Fuselage The passenger cabin-underfloor hold combination of the Vanguard led to the adoption of a "double-bubble" fuselage; the floor datum is at the junction of the two portions. The whole fuselage, with the exception of the nosewheel bay, radome and tail-cone, is pressurized to a dP of 6.5 lb/sq in.

Structure is conventional, open frames being fitted to stringers to which large skin panels are flush-riveted. The frames immediately adjacent to the door cut-outs are attached directly to the skin; half the load is taken in suitably reinforced plating and half in the boundary members, to guard against a failure of either being of a catastrophic nature. The windows, 26 by 19in ellipses, are basically identical with those of the Viscount; provision is made for 35 standard windows, with an additional four over the mainplanes which are also emergency exits, and four "port-hole" type to cater for the higher seating configurations. The areas between the windows are protected by tear-stopping, closely-pitched vertical stiffeners attached directly to the skin. The eleven large windscreen panels are carried in a forged frame. The upper floor, designed as a passenger and crew floor only, is composed of removable light-alloy panels stiffened by longitudinal channel sections. Rail fixings are employed for seats, bulkheads, and other furnishings. The freight floor is stressed to 150 lb/sq ft with a local intensity of 200 lb/sq in.

Six main doors, four giving access to the passenger compartment and two to the freight holds, open outwards and are sealed pneumatically. A valve prevents opening at a dP greater than 0.2 lb/sq in. The main entrance door, measuring 72 by 41in, is forward on the port side, and there is a second passenger entrance door of the same size at the aft end of the cabin. Both doors incorporate built-in hydraulically operated folding stairs. The latter are separate from the doors, which hinge outwards on parallel links to lie clear of the fuselage skin when the door is open. Opposite these doors are 64 by 26in emergency exits and pantry service doors and a third emergency exit, 48 by 24in, is provided to the rear of the main passenger door, on the port side. Each freight hold is served by counter-balanced doors 65in wide by 46in on the starboard side, split longitudinally and opening upwards and downwards.

Wing Within the 15 per cent section wing (tapering to 13 per cent at the tip) is a twin-cell torsion box structure comprising three shear webs and top and bottom integrally stiffened panels. The wing is divided into three main portions, the centre section (which contains no fuel), and the port and starboard mainplanes, each of which has a manufacturing joint immediately outboard of the outer engines. The wing comprises 54 stiffened panels tailored from stretch-levelled duralumin planks varying in length from 12ft to 29ft, in width from 26in to 30in, and in thickness from 1.75mm to 2mm. Top surface skins are D.T.D. 5020 (American equivalent 145-T6), and the lower tension skin is machined from material to the U.S. specificatin 24 S-T4.

The torsion box and its end ribs form the integral fuel tanks. Access to the interior of the tanks is gained through bolted panels in the top surface of the inner wings, and *via* access panels in the webs of the outer wings.

Tail The fin is divided into a lower portion attached to the same frames as the tailplane, and an upper section joined to the lower by suitable fittings and removable pins. The rudder is made as a single surface with a combined spring and trim tab along

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VANGUARD . . .

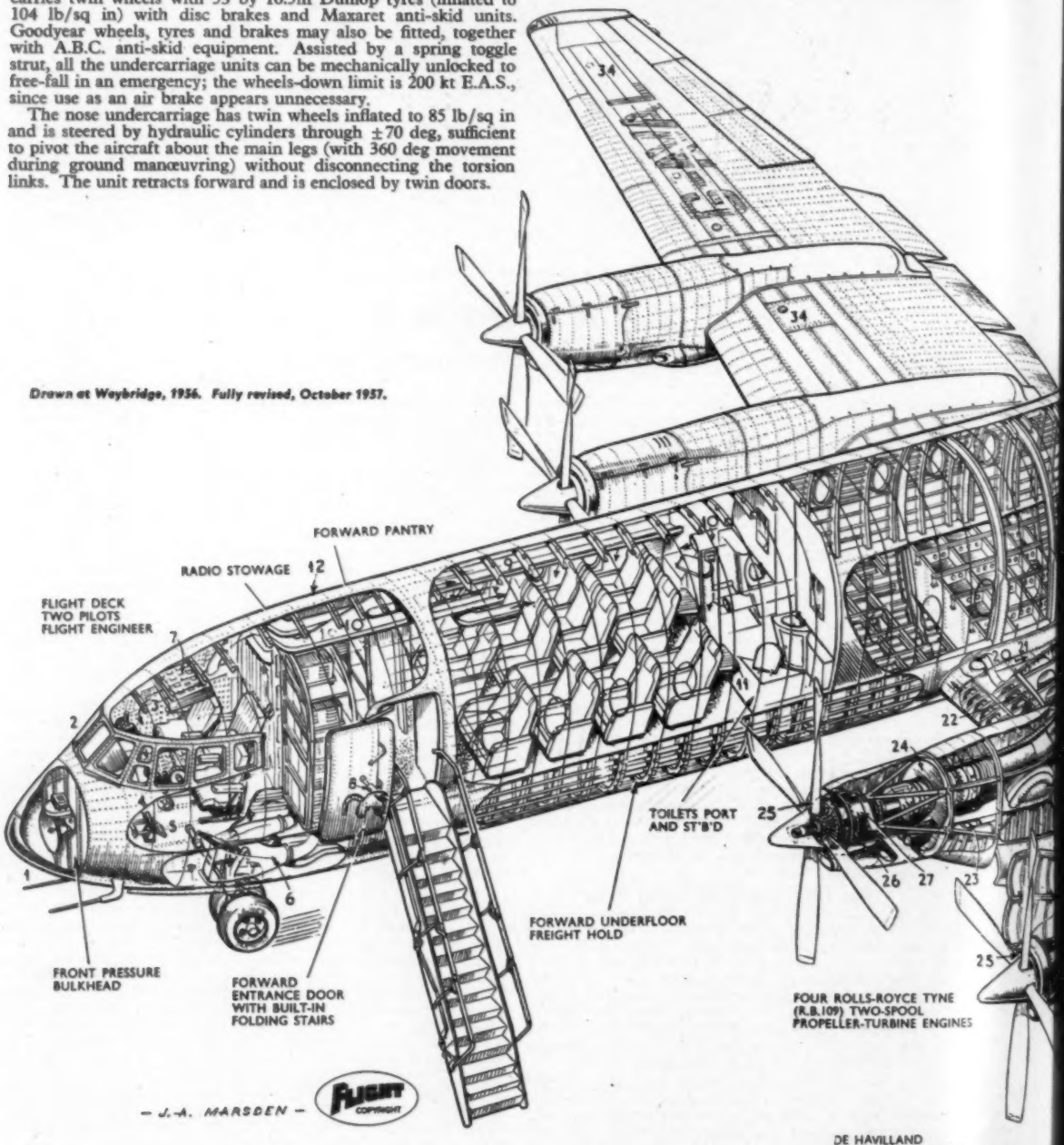
most of the length of the trailing edge. The structure is conventional. Each half of the tailplane has 15 deg dihedral, the thickness/chord ratio is 14 per cent at the root and 12 per cent at the tip. Three shear webs carry multiple ribs, and the leading edge, with its electro-thermal de-icing elements, is detachable. The elevators carry tabs (spring, balance and trim) along the greater length of the trailing edges.

Undercarriage The complete unit is a Vickers design. The identical port and starboard main legs are hinged to robust forgings beneath the wing torsion box; they are hydraulically retracted into the nacelle and closed by double doors. Each unit carries twin wheels with 53 by 16.5in Dunlop tyres (inflated to 104 lb/sq in) with disc brakes and Maxaret anti-skid units. Goodyear wheels, tyres and brakes may also be fitted, together with A.B.C. anti-skid equipment. Assisted by a spring toggle strut, all the undercarriage units can be mechanically unlocked to free-fall in an emergency; the wheels-down limit is 200 kt E.A.S., since use as an air brake appears unnecessary.

The nose undercarriage has twin wheels inflated to 85 lb/sq in and is steered by hydraulic cylinders through ±70 deg, sufficient to pivot the aircraft about the main legs (with 360 deg movement during ground manœuvring) without disconnecting the torsion links. The unit retracts forward and is enclosed by twin doors.

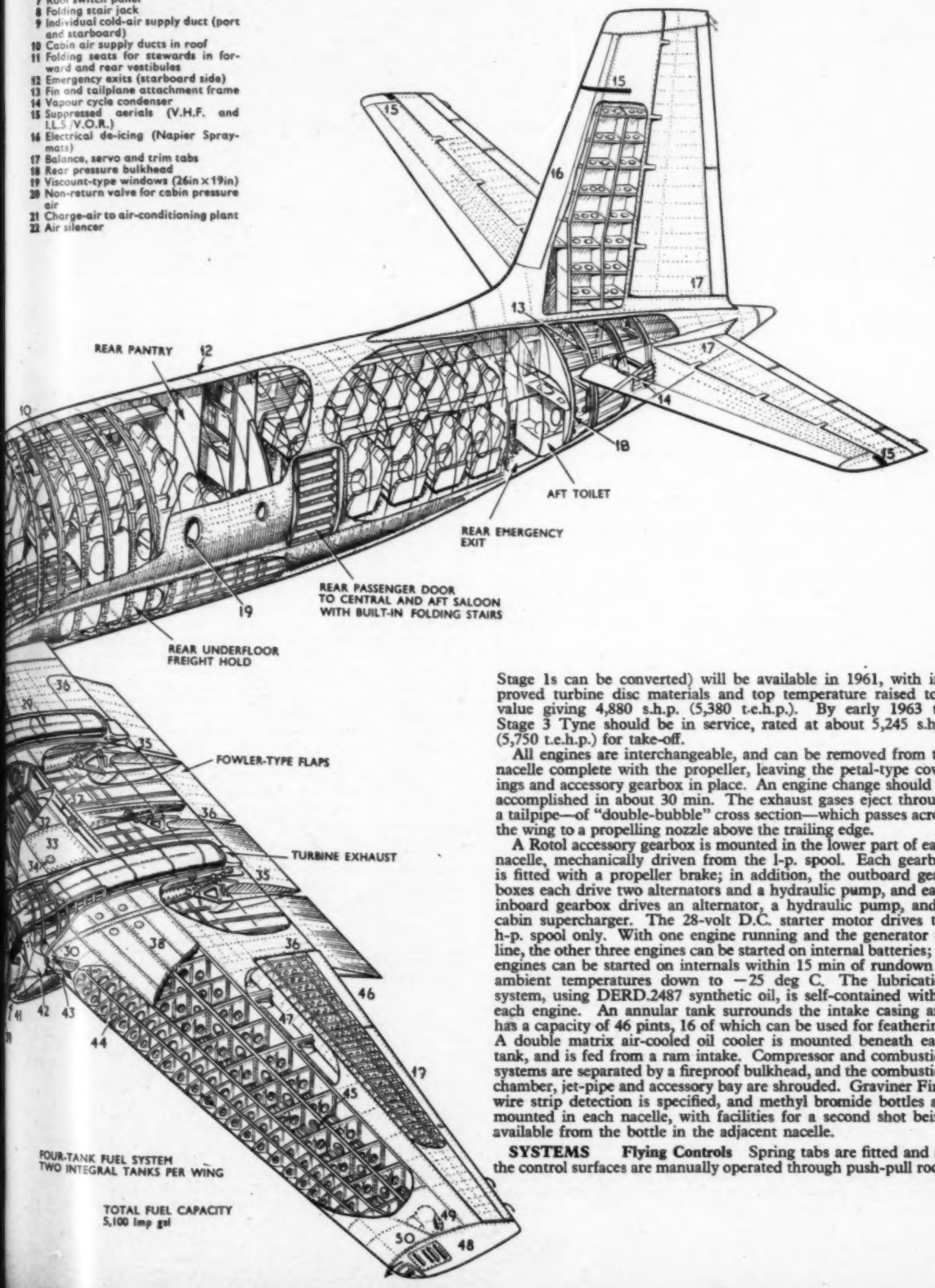
POWERPLANT The engines are Rolls-Royce Tyne 500-series turboprops. Each drives a 14ft 6in de Havilland four-bladed constant-speed propeller, fitted with overspeed pitch locks and automatic phase synchronizing, and incorporating auto-feathering, feathering and reversing. Nose cowl, propeller and spinner de-icing is performed electrically by means of external heater mats. Engine de-icing is by hot air from a compressor tapping.

The Tyne has a two-shaft, axial-flow compressor with a combined pressure ratio of 13 to 1. The high-pressure compressor is driven by its own turbine and the low-pressure compressor and propeller by a separate three-stage l-p. turbine, the shaft of which runs inside the self-contained h-p. assembly. Detail design improvements have raised the power that will be available from the "Stage 1" Tynes in 1959 for the first Vanguards from 4,020 s.h.p. to 4,310 s.h.p. (4,795 t.e.h.p.). Stage 2 engines (to which



Drawn at Weybridge, 1956. Fully revised, October 1957.

1 Fibreglass radome over cloud-collision-warning radar
2 Electrically heated and demisted windscreen panels
3 Air supply duct to flight deck
4 Adjustable control column
5 Engine, airscrew, flap and trimming control pedestal
6 Air conditioning heat exchangers. Cold-air unit and temperature control system (each side of nose-wheel bay)
7 Roof switch panel
8 Folding stair jack
9 Individual cold-air supply duct (port and starboard)
10 Cabin air supply ducts in roof
11 Folding seats for stewards in forward and rear vestibules
12 Emergency exits (starboard side)
13 Fin and tailplane attachment frame
14 Vapour cycle condenser
15 Suppressed aerials (V.H.F. and I.L.S./V.O.R.)
16 Electrical de-icing (Napier Spraymats)
17 Balance, servo and trim tabs
18 Rear pressure bulkhead
19 Viscount-type windows (26in x 19in)
20 Non-return valve for cabin pressure air
21 Charge-air to air-conditioning plant
22 Air silencer
23 Air filter, blower and silencer
24 Firewall
25 Main engine air intakes
26 Oil cooler
27 Integral engine oil tank
28 Access holes to integral tanks
29 Flattened tailpipe
30 Wing de-icing crossover pipe
31 Main undercarriage machined rib
32 Undercarriage retraction jack
33 Bolted access panel
34 Gravity fillers
35 Double-track flap guide ribs
36 Single-track flap guide ribs
37 Flap torque tube
38 Integrally stiffened wing torque box
39 Petal-type cowlings
40 Accessory gearbox
41 Air intake to de-icing heat exchanger
42 Heat exchanger (outboard nacelles)
43 Ventral exhaust gas outlet
44 De-icing hot-air duct
45 Intercommunicating holes in centre web
46 Spring tab
47 Aileron leading-edge beak
48 Detachable wing-tip
49 Landing lamp
50 De-icing hot-air outlet

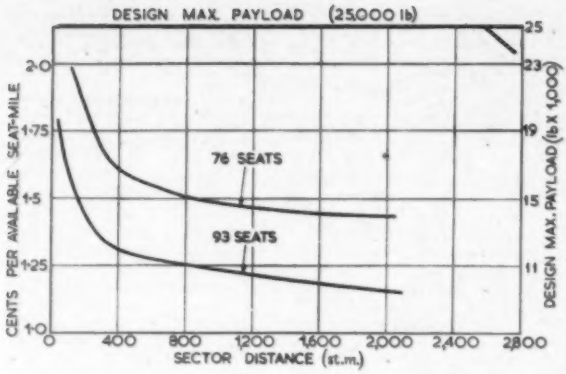

REAR PANTRY
AFT TOILET
REAR EMERGENCY EXIT
REAR PASSENGER DOOR TO CENTRAL AND AFT SALOON WITH BUILT-IN FOLDING STAIRS
REAR UNDERFLOOR FREIGHT HOLD
FOWLER-TYPE FLAPS
TURBINE EXHAUST
FOUR-TANK FUEL SYSTEM TWO INTEGRAL TANKS PER WING
TOTAL FUEL CAPACITY 5,100 Imp gal

Stage 1s can be converted) will be available in 1961, with improved turbine disc materials and top temperature raised to a value giving 4,880 s.h.p. (5,380 t.e.h.p.). By early 1963 the Stage 3 Tyne should be in service, rated at about 5,245 s.h.p. (5,750 t.e.h.p.) for take-off.

All engines are interchangeable, and can be removed from the nacelle complete with the propeller, leaving the petal-type cowlings and accessory gearbox in place. An engine change should be accomplished in about 30 min. The exhaust gases eject through a tailpipe—of "double-bubble" cross section—which passes across the wing to a propelling nozzle above the trailing edge.

A Rotol accessory gearbox is mounted in the lower part of each nacelle, mechanically driven from the l-p. spool. Each gearbox is fitted with a propeller brake; in addition, the outboard gearboxes each drive two alternators and a hydraulic pump, and each inboard gearbox drives an alternator, a hydraulic pump, and a cabin supercharger. The 28-volt D.C. starter motor drives the h-p. spool only. With one engine running and the generator on line, the other three engines can be started on internal batteries; all engines can be started on internals within 15 min of rundown in ambient temperatures down to −25 deg C. The lubrication system, using DERD.2487 synthetic oil, is self-contained within each engine. An annular tank surrounds the intake casing and has a capacity of 46 pints, 16 of which can be used for feathering. A double matrix air-cooled oil cooler is mounted beneath each tank, and is fed from a ram intake. Compressor and combustion systems are separated by a fireproof bulkhead, and the combustion chamber, jet-pipe and accessory bay are shrouded. Graviner Firewire strip detection is specified, and methyl bromide bottles are mounted in each nacelle, with facilities for a second shot being available from the bottle in the adjacent nacelle.

SYSTEMS **Flying Controls** Spring tabs are fitted and all the control surfaces are manually operated through push-pull rods.



Payload-range and direct operating costs for the Vanguard. Payload-range includes reserves for 230 st. m diversion and 1 hr holding at 5,000ft and complete operating allowances, and assumes I.S.A., still air, and 30,000ft cruise. Costs are based on the Lockheed method, including 15 per cent import duty. Price is about £800,000.

AIRLINERS OF THE WORLD

VANGUARD . . .

Elevator balance is 25 per cent by means of set-back hinges; the rudder has a rounded nose, with a small gap. Spring tabs are also used on the ailerons, which are otherwise similar to the Viscount, with a leading edge beak and fabric seal. The dual-control cockpit columns are pivoted at floor level. Mechanical locks—designed to meet tail gust loads of 80 kt—are connected to the engine throttles, to limit the power available for take-off, but leave sufficient power for taxying with the control locks engaged.

On each wing there are four sections of Fowler-type flap, the chord being constant throughout. The sections are mounted on bogies which move aft on rollers on steel guide rails and are operated by a single hydraulic jack in the inner wing, which rotates a torque shaft and operates the flaps through a cable system. Four inner tanks are formed within the wing box. Each inner tank has a capacity of 1,880 gal and each outer about 670 gal, giving a total capacity of 5,100 Imp. gal. Fuel supplied to the engine is continuously heated to prevent icing. Mass-flow fuel measuring equipment is fitted as standard, and fuel can be jettisoned. A single socket in the port wing root serves for pressure refuelling or defuelling; provision can also be made whereby this socket can be arranged to accommodate two refuelling/defuelling hoses. Maximum flow is 600 gal/min at 50 lb/sq in. Gravity fillers are fitted above the outer end of each tank. All tanks are equipped with capacity-type contents gauges and underwing fuel level indicators.

Cabin Air Design differential is 6.5 lb/sq in. Each inboard accessory gearbox drives a Godfrey blower of the S.R.M. type; normal supply from each is 150 lb/min, equivalent to a complete change of cabin air about 20 times per hour. Full pressure can be maintained with either blower alone. A cold-air unit (air-cycle turbine) is mounted forward of the front freight hold, and is fed through intercoolers from ram intakes in the fuselage nose. For operation in extreme climatic conditions, combustion heaters, or a closed-cycle Freon refrigerating system, can be incorporated. Without the latter, ground-conditioning can still be achieved by running an inboard engine (both of which are used for taxying), or by means of suitable ground conditioning equipment.

Air is introduced along the whole length of the cabin through the ceiling and extracted through louvres in the wall skirting. Temperature in the flight deck is selected by mixing air fed from separate hot and cold ducts, with independent control.

Hydraulics Lockheed hydraulic pumps are driven from the engine accessory gearboxes to pressurize the system to 3,000 lb/sq in. Hydraulic power is used to operate the undercarriage, flaps, brakes, nosewheel steering, windshield wiper parking and folding entrance stairs.

Electrics Power is supplied by six variable frequency A.C. alternators, four of which are coupled to transformer/rectifier units, each of which has an output of 500 amp 28 V D.C. for the main electrical system. In addition, these alternators supply power for their respective nose cowl, propeller and spinner de-icing systems. The remainder provide power for tail and windscreen de-icing. Voltage control is by means of carbon pile regulators, and storage batteries are carried under the floor. Two 28 V D.C. inverters provide 400 c/s three-phase 200 V A.C. supplies for instruments, autopilot and electronics.

Ice Protection As with the Viscount, the wing leading edge is thermally de-iced by ram air which has passed through heat exchangers, and heated by exhaust gases tapped from the outboard tailpipes. Temperature control is automatic. The leading edges of the fin and tailplane are heated by Napier Spraymat electrically heated elements Triplex Gold Film or Nesa glass is used in the transparent panels on the flight deck.

Flight Equipment The flight-crew accommodation is arranged for two-pilot operation with a third seat aft of the central control pedestal. B.E.A. and T.C.A. interiors differ in equipment, but for the B.E.A. Vanguard 951 the equipment specified includes the Smiths Flight System and S.E.P.2 autopilot. The cockpit is one of the most spacious and carefully thought out ever to be designed. Provision is made for the following aerials: nose radome weather radar; A.D.F. (semi-suppressed loop aerial above, sense aerial below fuselage); V.H.F. (external, one above, one below fuselage); I.L.S./V.O.R. (suppressed in top of fin; also pair of external blades on fin); Decca (suppressed under fuselage); transponder (under fuselage); H.F. (suppressed) wing root slot and rail-type marker (suppressed under fuselage); Tacan (external, under fuselage) and radio altimeter (suppressed, flush mounted horn).

PAYLOAD ACCOMMODATION A wide variety of interior layouts is possible and bars, pantries and bulkheads are removable; toilets are situated in the plane of the airscrew discs in all passenger versions. The standard V.951 has a 96-seat one-class interior with three compartments and a cabin crew of four. The Vanguard cabin can accommodate six-abreast seating with a capacity of up to 138 passengers. The seat pitching is variable from 34in to 39in. Upper and lower blinds are fitted in place of the more conventional curtains. The capacious freight holds under the floor area are 57.7 wide at floor level; the forward hold is 317in long (750 cu ft), and the rear 272in (610 cu ft).

In the freighter version of the Vanguard there is no less than 5,760 cu ft of space available in addition to the underfloor holds, giving a total volume of 7,120 cu ft. The underfloor width is restricted to 58in. The width of the two hold doors is 65in and in the upper compartment a freight loading door at the rear would provide a clear entrance space 70in high and 108in wide.

COMMERCIAL HISTORY The first aircraft, G-AOYW, is now under construction at Weybridge. Most of the integrally stiffened panels have been machined, and the shell of the first fuselage is rapidly taking shape. This Vanguard is scheduled to fly in the autumn of 1958 and will be retained by Vickers for an extended series of flight tests and demonstrations. The B.E.A. order was placed in October 1955 for 20 aircraft at a price, with spares, of approximately £1 m each.

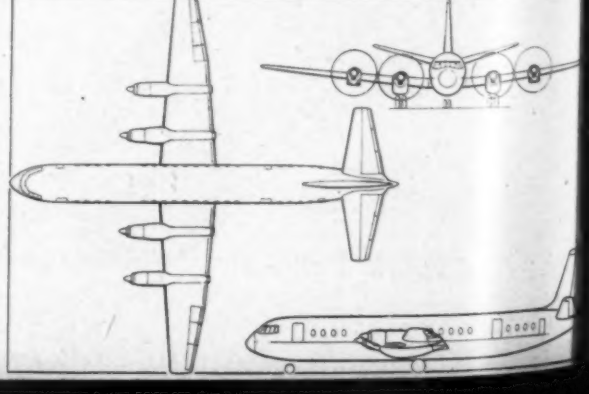
In January this year, after "one of the most exhaustive analyses ever undertaken," Trans-Canada Air Lines placed an order for 20 aircraft and parts worth £23.9 m, with an option on a further four aircraft. Modifications to the structure, increasing the payload to 25,000 lb and allowing full cruising power to be used at lower altitudes than originally envisaged, was made at T.C.A.'s request. Deliveries of the 951 to B.E.A. will begin in March 1960, and of the 952 to T.C.A. later in the same year; all the latter should be delivered in time for their 1961 summer schedules. By the end of 1960, it is hoped to have reached a production rate of four Vanguards per month.

VICKERS-ARMSTRONGS V.950 VANGUARD
Four Rolls-Royce Tyne (R.Ty.1) turboprops

Dimensions: Span, 118ft; length, 122ft 10.4in; overall height, 34ft 11in; track, 30ft 2.82in; wing area, 1,529 sq ft (gross), 1,347 sq ft (net); root chord, 205in; flaps, 161 sq ft per side; ailerons, 61 sq ft each, aft of hinge; tailplane, 236 sq ft; elevators, 146 sq ft; fin, 150 sq ft; rudder (aft of hinge line), 87 sq ft; max. fuselage cross section, 11ft 6in wide and 13ft 7.15in deep.

Weights: Maximum take-off, 141,000 lb; max. landing, 114,000 lb; max. zero fuel weight, 104,500 lb; design payload, 25,000 lb; max. payload, 27,000 lb; empty weight (B.E.A.), 72,299 lb; structure, 37,575 lb.

Performance: Design cruising speed, 425 m.p.h. at 25,000ft at 13,500 r.p.m. (3,195 e.h.p.; s.f.c., 0.388 lb/hr/e.h.p.); balanced field length (I.S.A., sea level at max. take-off weight), 6,500ft; range with max. payload (96 passengers and baggage and 7,800 lb freight), 2,600 st. miles, with 7,000 lb reserve fuel; climb (sea level, I.S.A., 120,000 lb, 170 kt e.a.s.), 2,350ft/min.



AIRLINERS OF THE WORLD

ELECTRA

Lockheed Aircraft Corporation (California Division), Burbank, California

AFTER many years of paper studies embracing a host of jet and propeller-driven projects, Lockheed finally evolved the Model 188 Electra as the aeroplane which they believe to be the optimum for intense short and medium-haul operations. American Airlines had been conducting similar studies and it was their formal specification—which was submitted to several major American manufacturers—which resulted in the actual Electra design. Lockheed claim that it is "the only turbine-age passenger transport designed to meet all requirements of short and medium haul operation . . . partner to the long-haul turbojet aeroplane."

It is exceedingly clean and well laid out. Numerous detail changes have been made to the design since it was described in our 1956 review of airliners, and these changes are commented upon in the ensuing paragraphs.

AIRFRAME All primary structure has been designed in accordance with fail-safe precepts and incorporates multiple load paths and reduced stress levels. As an example, no part of the skin of the pressurized fuselage has an operating stress greater than 12,000 lb/sq in. In all cases the Lockheed designers have adopted the optimum structure without regard to tooling costs and it is partly this which has resulted in the break-even production being exceptionally large.

Fuselage The Electra differs from most modern transports in that the cross section of the fuselage is a true circle over most of its length (because, say Lockheed, "it is the strongest and lightest structural shape for the required function"). Most of the structure is 7075 aluminium alloy with 2024 aluminium alloy used for skin panels and bulkhead webs subjected to tension loads through pressurization. Tension-type break joints are located at station 200, just behind the flight deck, and station 1118, the rear pressure bulkhead. The simple frames are generally spaced 19in and comprise lipped channels alternately facing fore and aft, and notched to receive the rolled-section stringers. Straps are then added around the frames between the stringers and the skin to form tear-stopping load paths. The complete constant-section pressurized hull is built from four quarter sections (top, bottom and two sides), the floor beams joining the bottoms of the side members.

At stations 570 and 695 are strong frames aligned with the wing spars. The stub-wing portion of the fuselage is a straight section of box beam which separates the hydraulic and electric service centres and extends 65in on either side of the aircraft centre-line. The front pressure bulkhead is a kinked and braced disc and the rear pressure dome is convex.

Wing Of neat, laminar-flow design, the Electra wing is based on a primary box beam consisting of two spars and upper and lower surfaces built up from integrally stiffened machined panels. These panels are of 7078 alloy on the upper surface but most of the remainder of the wing structure is in 7075 alloy.

Port and starboard wings are built separately and are bolted to the stub-wing box which extends just beyond the fuselage frames. Each wing box has considerable chord; the front of each box is straight, and parallel to the transverse axis of the aircraft, and the rear of the box is kinked at the inboard end of the aileron and has acute taper.

Fail-safe integrity is enhanced by various points of detail design. The vertical plate webs are divided into upper and lower sections which are joined by a double row of rivets. Each web is then stiffened by extruded booms and vertical angles riveted on. Between the widely spread spars is a network of closely spaced ribs each built up from Warren girders fabricated from angle sections with a peripheral member notched to match the integrally machined skins. The latter have a ruling width of some 20in and contain about six spanwise stiffening webs. Joints between the machined planks are of the lap-type with double rivet rows. The front three panels are unbroken from root to tip and additional panels are brought in at the root to fade out on the taper of the rear spar. Behind the rear spar the secondary structure comprises an outer skin stiffened by a bonded inner sheet provided with cut-outs and stiffeners.

Notes on the flaps, ailerons and de-icing are provided later in this account. The leading edge incorporates thermal anti-icing and is designed to suffer minimum deformation as a result of hail or other impact damage. All structure ahead of the wing box inboard of the outer engines is designed to hinge downwards to provide access to systems.

Tail Unit Lockheed state that the tail structure "is designed to withstand at ultimate strength the yawing moment loads resulting from an outboard engine turbine failure coupled with simultaneous failure of all engine and propeller safety devices and adverse pilot reaction under critical altitude, speed and temperature conditions." Northrop Aircraft have had prime responsibility for the design and manufacture of the Electra empennage and numerous detail changes have been incorporated since the original configuration was projected.

Basically the structure is conventional with spars, ribs and skin in a ruling material of 7075 alloy. The vertical fin has two main spars growing out of the fuselage frames, the front spar being raked backwards some 6ft above the upper line of the fuselage. Incorporated in the fin are structural-plastic V.O.R. windows and provisions for hot-air de-icing. Each half-tailplane is joined to the fuselage outboard of the root fillets and picks up on a short centre section built as an integral part of the tail cone. The two principal spars are at 19 per cent chord and at the trailing edge of the tailplane itself and the ribs are lattice girders, as in the wing, which carry heavy extruded stringers on which the skin is supported. The rudder and elevators have thin skins stabilized by thin "waffle" sheet bonded on, as shown in the large drawing.

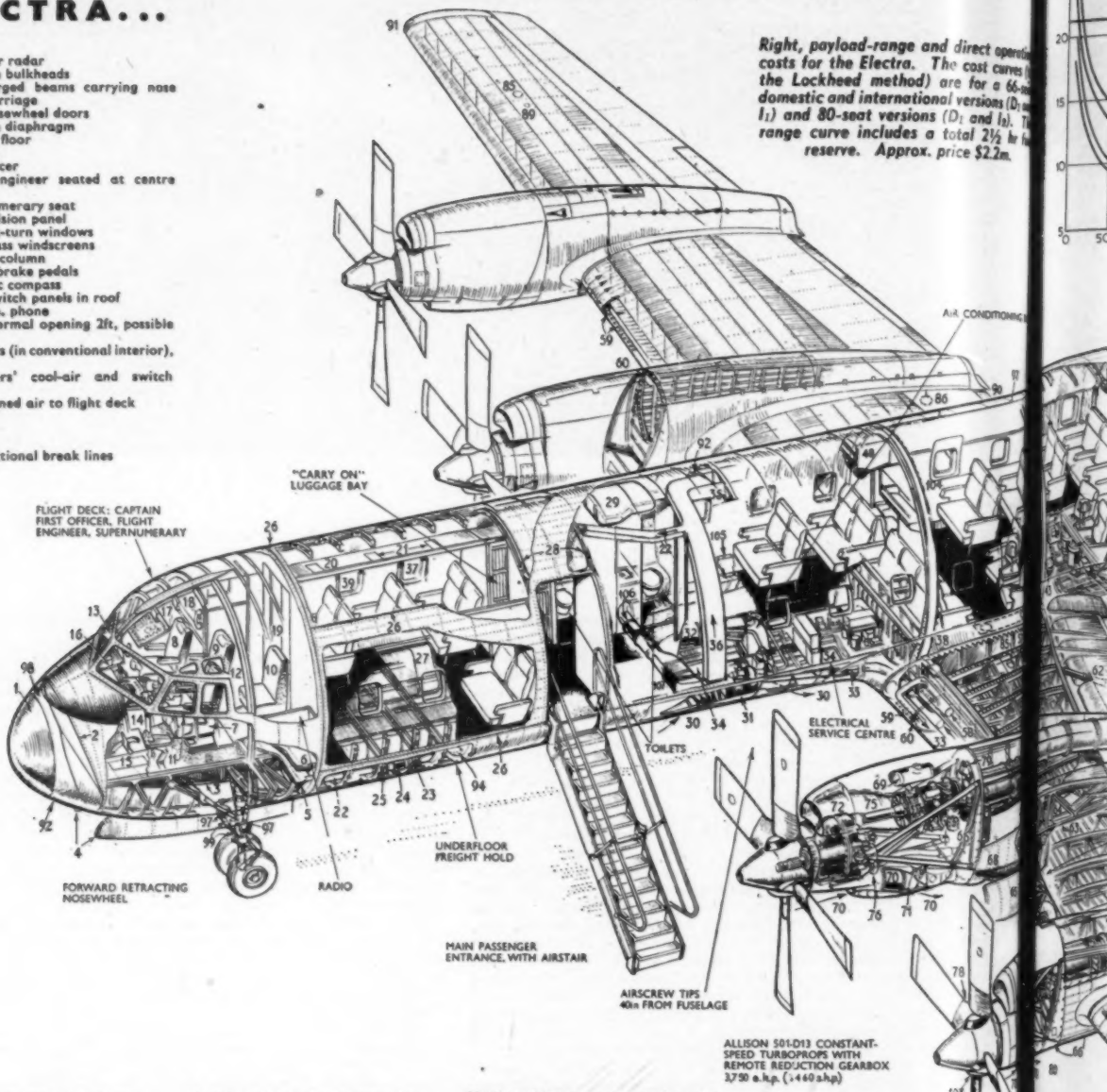
Undercarriage Designed and manufactured by Menasco, the Electra gear is both sturdy and neat, and is quite conventional. Each main leg is a single forging braced by pin jointed upper and lateral arms on either side fabricated in heat-treated steel. This assembly is carried outside the wing box on large forged truss ribs each just outboard of the inboard nacelle on each wing. The drag strut has a Y fork, at the junction of which is a bungee-loaded

AIRLINERS OF THE WORLD

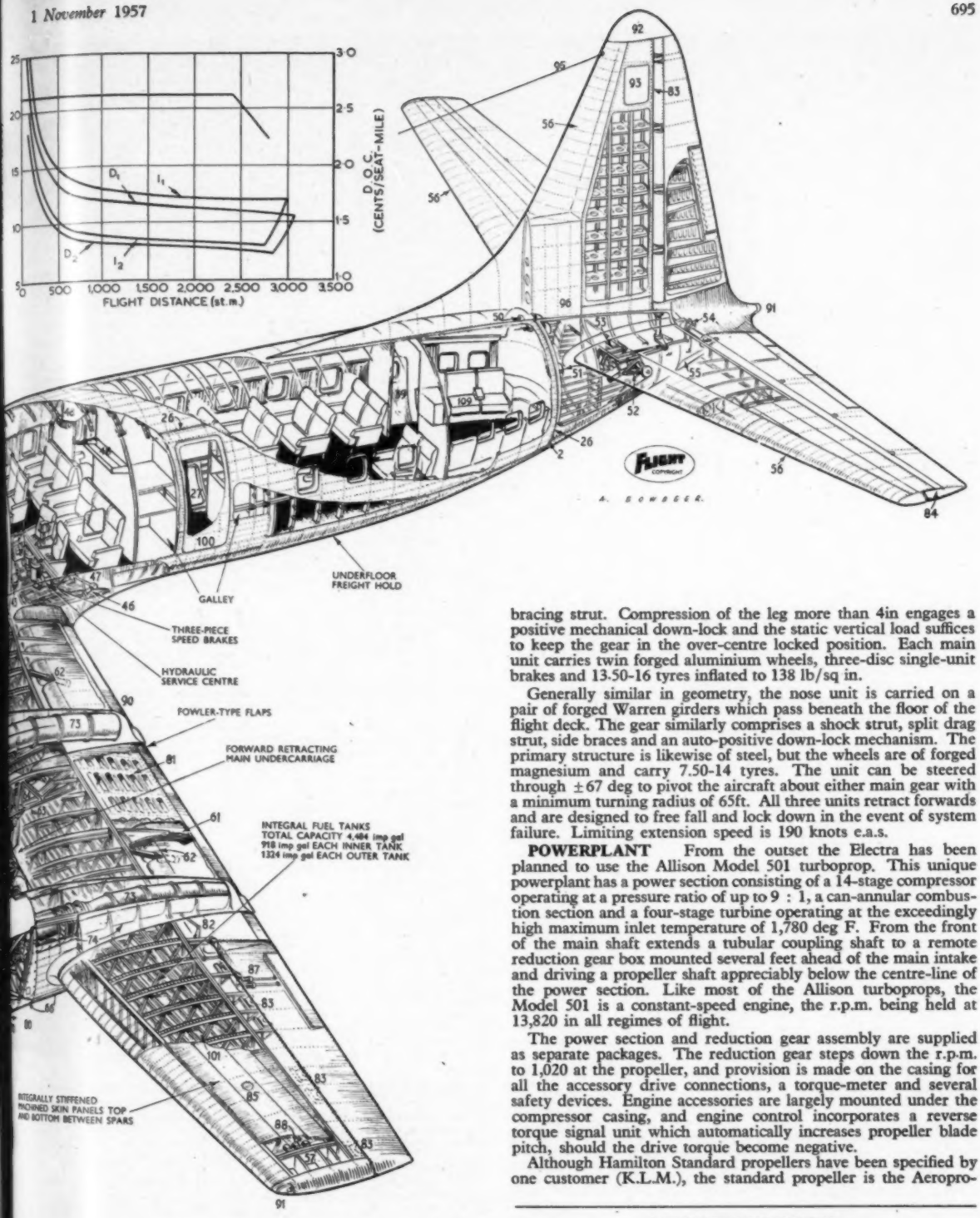
ELECTRA...

Drawn at Burbank May 1956; extensively modified October 1957

Right, payload-range and direct operating costs for the Electra. The cost curves (by the Lockheed method) are for a 66-seat domestic and international versions (D_1 and I_1) and 80-seat versions (D_2 and I_2). The range curve includes a total 2½ hr fuel reserve. Approx. price $2.2m.


"CARRY ON" LUGGAGE BAY
FLIGHT DECK: CAPTAIN FIRST OFFICER, FLIGHT ENGINEER, SUPERNUMERARY
FORWARD RETRACTING NOSEWHEEL
RADIO
UNDERFLOOR FREIGHT HOLD
TOILETS
ELECTRICAL SERVICE CENTRE
MAIN PASSENGER ENTRANCE, WITH AIRSTAIR
AIRSCREW TIPS 40in FROM FUSELAGE
ALLISON 501-D13 CONSTANT-SPEED TURBOPROPS WITH REMOTE REDUCTION GEARBOX 3,750 e.h.p. (+460 a.h.p.)
AEROPRODUCTS AIRSCREWS 13ft 6in dia

1 Weather radar
2 Pressure bulkheads
3 Two forged beams carrying nose undercarriage
4 Twin nosewheel doors
5 Pressure diaphragm
6 Cockpit floor
7 Captain
8 First officer
9 Flight engineer seated at centre console
10 Supernumerary seat
11 Direct-vision panel
12 Vision-in-turn windows
13 Nesa glass windscreens
14 Control column
15 Rudder/brake pedals
16 Magnetic compass
17 Large switch panels in roof
18 Intercom. phone
19 Door, normal opening 2ft, possible 4ft
20 Hat racks (in conventional interior), see 48
21 Passengers' cool-air and switch panels
22 Conditioned air to flight deck
23 Fan
24 Filter
25 Heater
26 Constructional break lines
27 Sliding plug-type freight door
28 Passenger-door rails and rollers
29 Fresh-water tank
30 Airflow through heat exchanger
31 Twin air-cycle unit
32 Condenser/fan unit
33 Cabin air from compressors on inboard gearboxes
34 Central access hatch
35 Roof ducting, air-conditioning
36 Conditioned-air riser to 35
37 Windows 16in x 18in
38 Wing/fuselage joint, front and rear spars
39 Emergency exits
40 Aileron hydraulic booster unit on rear spar
41 Pilot-input cables to 40
42 Brake accumulator
43 Emergency brake air bottle
44 Hydraulic pumps (electrically driven)
45 Hydraulic reservoirs, 3,000 lb/sq in system
46 Speed-brake panels
47 Speed-brake screw-jack
48 Transverse hat racks (club interior)
49 Lamp and table between club chairs
50 Pressure outflow valves
51 Inflow valve
52 Rudder booster unit (port)
53 Elevator booster unit (starboard)
54 Universal joint in elevator tube
55 Access hatch
56 Tail hot air anti-icing
57 Tank end-ribs
58 Engine bleed-air for wing anti-icing
59 Hot-air injectors (40 per foot) and double skin
60 Leading edge hinged for inspection
61 Flap track and roller assemblies (five each side)
62 Flap actuators
63 Forged ribs carrying main undercarriage
64 Undercarriage jack
65 Four doors to each main-wheel box
66 Firewalls
67 Multi-disc brakes
68 Wheel box
69 Oil tank
70 Airflow through oil cooler
71 Oil-cooler flap jack
72 Engine-air intake
73 Jet pipes
74 Stainless-steel heat-resistant trough
75 Engine drive-shaft to reduction gearbox
76 Cabin air compressor
77 N.A.C.A. intake to 76 (inner engines only)
78 Electrically de-iced blade-cuffs and blade-islands. Spinner anti-icing
79 Main engine-mounting point
80 Air turbine starters on each engine
81 Bonded double skin
82 Aileron linkage
83 Mass balances
84 Horn/mass balance
85 Gravity fuel filler
86 Pressure-refuelling point (under nacelle)
87 Twin (fail-safe) trim actuator
88 Fuel vent valves
89 Fuel probes
90 Fuel dump valves in this area
91 Navigation lights
92 V.H.F. aerial
93 V.O.R. aerial window
94 D.M.E. aerial
95 H.F. aerial
96 Integral fin and rear fuselage
97 Landing/taxi lights
98 Glide slope aerial
99 Steering cylinders
100 Passenger or galley service door
101 Tank-inspection panels
102 A.D.F. loop and sense aerials under belly
103 Variable low-pitch stop
104 Electrically heated wall panels
105 Cabin air for recirculation
106 Recirculating fan
107 Heater and Freon evaporator
108 Freon compressor
109 Six-seat lounge



bracing strut. Compression of the leg more than 4in engages a positive mechanical down-lock and the static vertical load suffices to keep the gear in the over-centre locked position. Each main unit carries twin forged aluminium wheels, three-disc single-unit brakes and 13·50-16 tyres inflated to 138 lb/sq in.

Generally similar in geometry, the nose unit is carried on a pair of forged Warren girders which pass beneath the floor of the flight deck. The gear similarly comprises a shock strut, split drag strut, side braces and an auto-positive down-lock mechanism. The primary structure is likewise of steel, but the wheels are of forged magnesium and carry 7.50-14 tyres. The unit can be steered through ±67 deg to pivot the aircraft about either main gear with a minimum turning radius of 65ft. All three units retract forwards and are designed to free fall and lock down in the event of system failure. Limiting extension speed is 190 knots e.a.s.

POWERPLANT From the outset the Electra has been planned to use the Allison Model 501 turboprop. This unique powerplant has a power section consisting of a 14-stage compressor operating at a pressure ratio of up to 9 : 1, a can-annular combustion section and a four-stage turbine operating at the exceedingly high maximum inlet temperature of 1,780 deg F. From the front of the main shaft extends a tubular coupling shaft to a remote reduction gear box mounted several feet ahead of the main intake and driving a propeller shaft appreciably below the centre-line of the power section. Like most of the Allison turboprops, the Model 501 is a constant-speed engine, the r.p.m. being held at 13,820 in all regimes of flight.

The power section and reduction gear assembly are supplied as separate packages. The reduction gear steps down the r.p.m. to 1,020 at the propeller, and provision is made on the casing for all the accessory drive connections, a torque-meter and several safety devices. Engine accessories are largely mounted under the compressor casing, and engine control incorporates a reverse torque signal unit which automatically increases propeller blade pitch, should the drive torque become negative.

Although Hamilton Standard propellers have been specified by one customer (K.L.M.), the standard propeller is the Aeropro-

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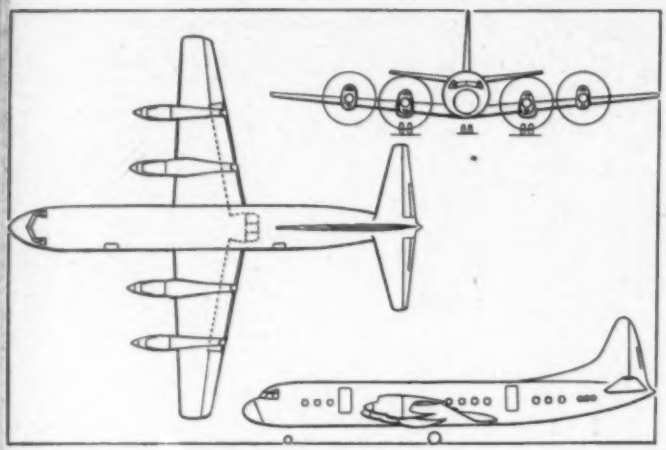
LOCKHEED L.188 ELECTRA

Four 3,750 e.s.h.p. Allison 501 D-13 turboprops

Dimensions: Span, 99ft; gross wing area, 1,300 sq ft; span of horizontal tail, 42ft 10in; overall length, 104ft 6.5in; fuselage outside diameter, 136in; inside diameter, 128in; overall aircraft height, 32ft 9.2in; track, 31ft 2in; wheelbase, 37ft.

Weights: Basic operating weight, 59,338 lb; max. weight, 113,000 lb; take-off weight for 500-mile flight, 95,000 lb; "normal landing weight with 85 passengers and reserve fuel," 88,733 lb; design landing weight, 95,650 lb; max. zero-fuel weight, 80,910 lb in current Electras, increased to 86,000 lb in future production; payload, 21,195 lb (space limited) in current aircraft, increased to 26,500 lb (weight limited) in later machines.

Performance: Typical cruising speed is quoted as 403 m.p.h. (weight not stated); take-off field length (standard day, 113,000 lb), 5,470ft; (hot day, +40 deg F), 7,550ft; landing field length (standard day, 95,650 lb), 5,400ft; climb at 113,000 lb, 15,000ft in 13 min or 20,000ft in 23 min.



AIRLINERS OF THE WORLD

ELECTRA . . .

ducts A6441FN-606. This unit incorporates extensive de-icing (*q.v.*) and is supplied with spinner, manual and auto-feathering and reversing systems. Its own self-contained oil and hydraulic systems provide full protection and selective pitch control, negative-torque control, synchronization and "blade-phase" governing. Each blade is approximately 18.5in wide and consists of a thrust member and camber surface (both of sheet-steel), brazed together along their edges. Overall diameter is 13ft 6in.

Each powerplant is supplied as a self-contained package which, together with the nacelles and tail pipes, is sub-contracted to Rohr Aircraft. The large drawing clarifies most of the installational details. Propeller thrust and torque are absorbed *via* steel-tube trusses through the first and second fire-walls, and so down into the wing box. Each tail pipe lies in a stainless-steel trough supported by transverse trunnions. The oil tanks are mounted directly above the engines and a drum-type cooler is situated low down under the main power section fed from a ram intake underneath. A considerable amount of the nacelle skinning is titanium.

Originally the Electra was to have had a novel starting system (described in our July 6 issue last year), but this has now been abandoned in favour of four identical pneumatic starters, one mounted on each engine. The first engine is started by coupling an air hose from a ground supply trolley and the remaining three by air bled from the compressors of engines already running. In view of the relatively small mass flow of the engines it is surprising that bleed air is also employed for extensive anti-icing purposes, as described in that section.

SYSTEMS **Flying Controls** Like the L.1649 and C-130, the Electra has manual controls in which pilot effort is amplified by hydraulic booster units. These boosters retain a definite "feel" on the pilots' controls, and each unit has a by-pass mechanism which, in the event of hydraulic failure, reduces the limits of travel of the surface concerned and increases the mechanical advantage, thus providing for manual control.

As the main drawing shows, the aileron booster is located in the hydraulic service centre. It is controlled by a closed-loop cable from the flight-deck and actuates the ailerons through spanwise push-pull rods. Elevator and rudder boosters are in the tail-cone and operate through similar circuits. The booster units are products of Bendix (Eclipse-Pioneer), who also make the Electra autopilot. The latter, one of the PB-10 series, has hydraulic servos which are integral with the boosters. The boosters also double as the system limit-stops and as gust-dampers.

Each half-wing carries a single large flap. These surfaces are of the Fowler type, and they run out on tracks to increase area without greatly increasing drag until, near the end of their extension, they encounter "quick cams" which rapidly depress them to the full deflection of some 70 deg. Actuation is by duplicated hydraulic motors driving torque tubes and triple-extension, ball-bearing screw-jacks. Incremental pre-selected positioning is obtained from the cockpit control lever and a follow-up cable.

Around the underside of the fuselage, in line with the trailing edge of the wing, are three door-type air brakes operated by a separate hydraulic motor and screw-jack. These surfaces follow the angular depression of the flaps, and they can also be controlled independently for use as a speed brake. It is possible to set them to any of various incremental positions.

Fuel The entire wing box is subdivided to form integral tankage on a "four-tank system" basis. Features include conventional auto-trimming and cross-feed, individual accessories for each powerplant, dumping, venting, gravity over-wing fuelling and a single pressure-fuelling socket in the rear of the No. 3 engine nacelle.

Capacity of each inboard tank is 908 Imp. gal, and the outers each contain 1,324 gal; unusable fuel is calculated at the low value of about 7 gal per tank. Dry bays are restricted to the region of the main undercarriage beams. Originally the tankage was vented through combined pipes leading to the wing tips; now each tank has its own vent, flush with the wing under-surface, and the ailerons extend right to the tips. The pressure-fuelling socket feeds a combined spanwise manifold at up to 250 gal/min. The same manifold links all four tanks for de-fuelling purposes, and it also serves a retractable jettison pipe on each side of the aircraft through which all but about 112 gal from each tank can be discharged.

Hydraulics There are two completely independent 3,000 lb/sq in systems, each energized by 6.7 gal/min pumps driven by A.C. electric motors. The primary system includes two pumps and drives the No. 1 control booster cylinders, the No. 1 flap motor, speed brakes, undercarriage, steering, wheel brakes, windscreen wipers and—if installed—stairways. When A.C. power is unavailable this system can be operated by a battery-fed D.C.-driven pump. The secondary system has one pump and drives the No. 2 boost cylinder and No. 2 flap motor. All main system units are grouped in a service centre under the floor.

Electrics The electrical system is unusual in that, although the primary loads are generated at 400 c/s, the alternators are not paralleled. Each of the propeller gearboxes carries a 60-kVA General Electric alternator; three of these are geared and one is direct-driven. Each supplies a three-bus system feeding selected groups of services. Although not paralleled, the alternators automatically share loads in the event of failure. D.C. supplies are obtained at 28 V from a pair of 150-amp transformer/rectifier units.

De-icing In the final arrangement, bleed air from the engines is used to provide thermal de-icing of the complete wing and tail unit. The air is taken through a 3½in duct along each wing ahead of the front spar; it is then piped to spanwise tubes along the leading edge provided with nozzles directed at the outer skin. The hot air then spreads back along an ¼in inter-skin space extending back through 15 per cent of the chord. A similar arrangement is employed on the tail. Ducting is corrosion-resistant steel, wrapped in glass-fibre overlaid with stainless foil.

Each engine air intake is heated by bleed air, but the propellers are heated electrically. The spinners have electric mats taking 16 kW continuous (8 kW per phase) from an alternator. The blades have intermittent de-icing on the root cuffs and "islands." Fed by the third phase of the propeller alternator, each opposite pair of blades takes 6 kW during a 12 sec "on," 84 sec "off" cycle.

Air-conditioning The cabin is pressurized to a dP of 6.5 lb/sq in by compressors driven off the inboard engines and fed from the main intakes. Total supply is 75 lb/min at 30,000ft. Heating is unusual in that electric radiant elements, taking up to 18 kW, are fitted in the cabin floor and wall panels. Ventilation air is fed beneath the hat racks at very low velocity. Cabin-cooling is provided by a 6.6-ton air-cycle system, supplemented by a 10-ton Freon system. Air from the cabin is extracted at high velocity along the roof centre-line.

FLIGHT DECK Exceptional study, over more than five years, has led to the existing standard layout, which provides for two pilots, an engineer (central) and a supernumerary behind on the port side. The engineer monitors the main flight-deck panels, all systems controls and instrumentation being on the centre and roof panels. Pilot view is 15 deg down over the nose, 20 deg up, and through 224 deg in azimuth. Provision is made for all normal electronic equipments, including weather radar. The loop and sense aerials are flush under the centre fuselage.

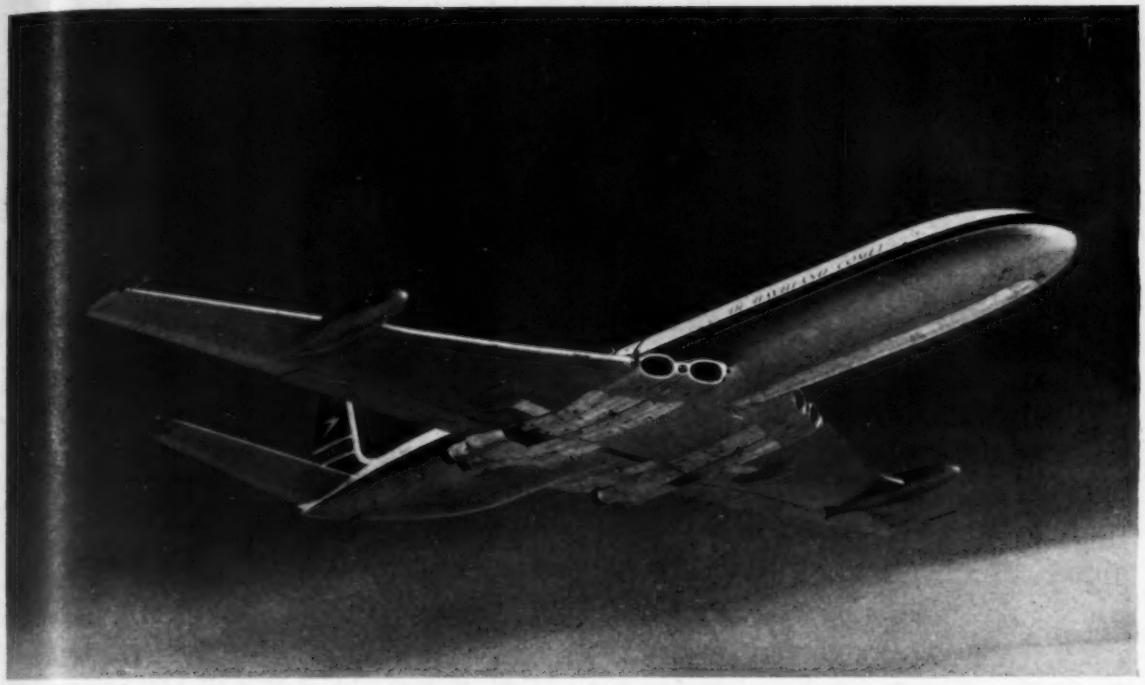
PAYLOAD ACCOMMODATION On a total usable floor area of 710 sq ft Lockheed have evolved four chief interiors. The 66-seat "custom" layout uses 20in seats four-abreast, with a 26in aisle, together with a rear six-feet lounge. The "standard" seating accommodates 85, with 18in seats five-abreast with a 17in aisle. The remaining configurations are the 81-seat mixed arrangement and the novel 71-seat "club" interior, evolved by American Airlines and shown in the large drawing. All arrangements have overhead racks incorporating lights, call-buttons, air louvres and oxygen connections.

Under the floor are two cargo compartments, with capacities of 254 and 270 cu ft. The forward hold is ventilated and electrically heated for animal transport. Carry-on baggage space is also provided, totalling 108 cu ft. In order to speed-up ground handling, Lockheed and American Airlines have evolved for the Electra a system of pre-loaded baggage bins for the forward cargo compartment. Each bin will be 36in wide, 77in long and 24in deep, and will be made of glass fibre. These will be loaded at the ticket counter and hoisted electrically into the Electra in a few seconds.

COMMERCIAL HISTORY When the Electra was first announced it was naturally coupled with American Airlines, who sponsored the design and ordered 35. Subsequent orders include those of Eastern (40, with an option on 30); Braniff, 9; National, 23; K.L.M., 12; Western, 9; Allison (General Motors), 1; Icelandic Airlines (Loftleidr), 2; Braathens, 1; Garuda, 3; Pacific Southwest, 3; Cathay Pacific, 2; and A.N.A., 4.

The rapid progress that has been made with the first aircraft in the past few months is the result of an extensive sub-assembly programme by Lockheed earlier in the aircraft's life. The tubular fuselage section went for final assembly in June, the nose was added in July, the wings and tail in August, the wiring and systems in September and undercarriage and tail shortly afterwards.

The photograph on p. 693 (taken five weeks ago) shows the first machine virtually complete. This aircraft has always been due to fly on January 31 next and should do so. The first four Electras will be engaged in flight testing and may later be sold. The fifth will be the first for an operator, and, after certification trials, is scheduled for Eastern Airlines next September 30. The sixth machine will go to Allison Motors. Production, which is fairly extensively sub-contracted, is building up to 12 per month. Lockheed see a market for at least 400. Recent changes include a valuable increase of 5,090 lb (5,040 effective) in zero-fuel weight and the availability of water injection for high-altitude field operations. Lockheed also envisage the possibility of 120 seats in a "thrift-class" operation.



AIRLINERS OF THE WORLD

COMET 4 and 4B

de Havilland Aircraft Co., Ltd., Hatfield, Herts.

IN a world transport market which, as each month goes by, appears to become more receptive to the idea of jet propulsion for medium- and short-range operations, the Comet stands out as the most tested and developed aeroplane available. Two versions are offered: the intercontinental Comet 4, and the continental, or short-to-medium-range, Comet 4B. The 4 has been ordered by B.O.A.C. (19), and the 4B by B.E.A. (6).

The 4B is a recent Comet development, announced last May. It is the version which—because it is claimed to offer 15 per cent better economy on the shorter stage-lengths—today figures more prominently in airline route-studies. Deliveries are offered in 1960.

Two market trends inspired de Havilland to develop the Comet 4B: the speed challenge of the new American jets, and the economy challenge of the new turboprops. Compared with the Comet 4, speed was increased by changing the cruising technique and by reducing drag, and economy was improved by an increase in payload and a reduction in first cost.

The change of cruising technique, and the structural changes which made this possible, are the most significant features of the 4B. The operational flexibility which results is explained as follows.

For maximum block-speed over relatively short stages the 4B can be flown at medium altitudes, thus increasing the true air speed at the limiting Mach number. This procedure enables the 4B to cruise at speeds of between 520 m.p.h. and 545 m.p.h. (depending on temperature) at its optimum altitude of 23,500ft. With this operating procedure the Comet 4B can carry a capacity payload of 19,680 lb (representing 84 first-class passengers and freight) over stages of up to 1,800 miles.

The alternative method of cruising, in which the aircraft is climbed to 38,000ft and cruised at 490 m.p.h. to 500 m.p.h., will extend the range to about 2,350 miles with a capacity of 19,680 lb. When even longer stages are involved then the 4B becomes less of a proposition than the Comet 4. (It may be noted that the Comet 4 can also be operated, on the shorter routes, using the high-speed cruise procedure. In this case the cruising speed of the Comet 4 will be lower than that achieved by the 4B, for structural reasons, and the cost per seat-mile will be somewhat higher, but the Comet 4 is claimed to be capable of profitable operation on routes down to 500-600 miles in length.)

The case for the new Comet 4B was expressed by the manufacturers as follows shortly after the 4B was announced.

"The new Comet is the only developed jet airliner in the world. It is designed to bring the revolutionary standards of jet speed and travelling comfort—first realized by de Havilland—to routes on which the traffic density and the stage lengths are moderate. Such conditions prevail on most of the world's trade network. . . . The new Comet with its Rolls-Royce Avon RA.29 is twice as powerful and half as large again as the Ghost-engined Comet which proved the advantages and economics of the basic Comet formula in 30,000 hours of regular airline operation.

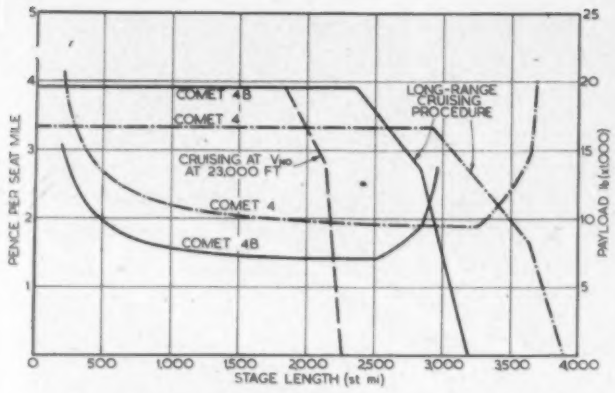
"The Comet is fully competitive as to operating cost with comparable aircraft of any type. Able to pay its way on a low load factor, it is nevertheless assured a high load factor by reason of its outstanding passenger appeal. . . . The Comet is designed to lift its full capacity payload and fuel load easily out of airports of moderate size such as are provided already throughout the five continents without any demand for the lengthening or strengthening of runways.

"The Comet has behind it a structural testing programme the scope of which has never been surpassed. Many thousands of static and fatigue tests involving large and small components and complete aircraft have been conducted progressively over more than ten years and have covered every part of the aircraft's structure."

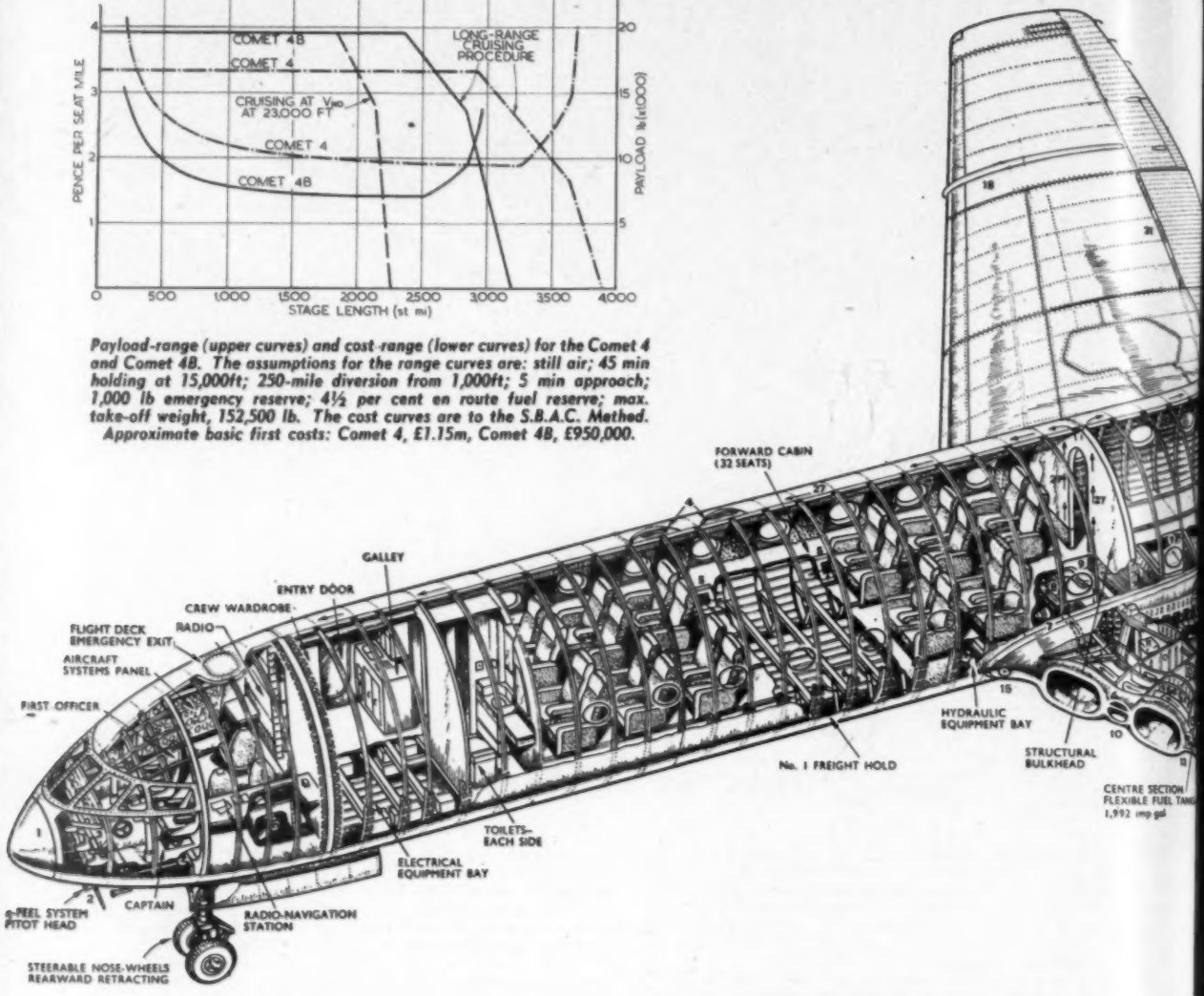
The following general description relates, except where otherwise stated, to both Comet 4 and 4B.

AIRFRAME In general, fuselage skin thickness is 19-gauge and nominal stress level is of the order of 22 per cent of ultimate. The fuselage is of conventional construction, being a semi-monocoque of stressed skin and stringers supported by transverse frames. All doors, hatches and exits are inwards-opening. Cabin windows are of double Perspex construction, the outer panel being the load-carrying member. Two equipment bays fore and aft of the forward freight hold (see drawing) respectively house and separate the majority of the equipment associated with the electrics and hydraulics.

The wing is of cantilever construction comprising a centre



Payload-range (upper curves) and cost-range (lower curves) for the Comet 4 and Comet 4B. The assumptions for the range curves are: still air; 45 min holding at 15,000ft; 250-mile diversion from 1,000ft; 5 min approach; 1,000 lb emergency reserve; 4½ per cent en route fuel reserve; max. take-off weight, 152,500 lb. The cost curves are to the S.B.A.C. Method. Approximate basic first costs: Comet 4, £1.15m, Comet 4B, £950,000.



AIRLINERS OF THE WORLD — COMET 4 and 4B . . .

section, two stub wings and two extension-wings. The centre section, unpressurized, accommodates four flexible fuel tanks. The stub wings are two-spar structures carrying the engines and undercarriage, containing integral and flexible fuel tanks, part of the flaps, and the speed brakes. Fin and tailplane are of conventional construction. The main undercarriage gear, of de Havilland design, consists of two four-wheel bogies and a two-wheel steerable nose gear. Their operation is hydraulic. The wheel brakes are Dunlop disc units incorporating the Maxaret anti-skid device.

POWERPLANT The Comet 4 and 4B are powered by four Rolls-Royce Avon RA.29 turbojets developing 10,500 lb sea level static thrust each. They are mounted between the front and rear main spars of each stub wing, and are insulated from one another and from the adjoining structure by titanium fire-walls. The outboard engines incorporate the Rolls-Royce thrust-reverser and a Rolls-Royce noise-suppression device is installed on each of the four engines. The engines and their components are interchangeable as far as possible with the exception of the jet pipes (although the inboard pipes and the outboard pipes are interchangeable). The underside of each engine can be completely exposed for servicing by large doors, and further access panels are provided on the top side for slinging and for top-accessory servicing. Most of the accessories, however, are beneath the engine, and are accessible from ground level. The combustion zones of each engine are separated from each other and are independently ventilated and cooled. Each zone has its own fire detection and extinguishing system.

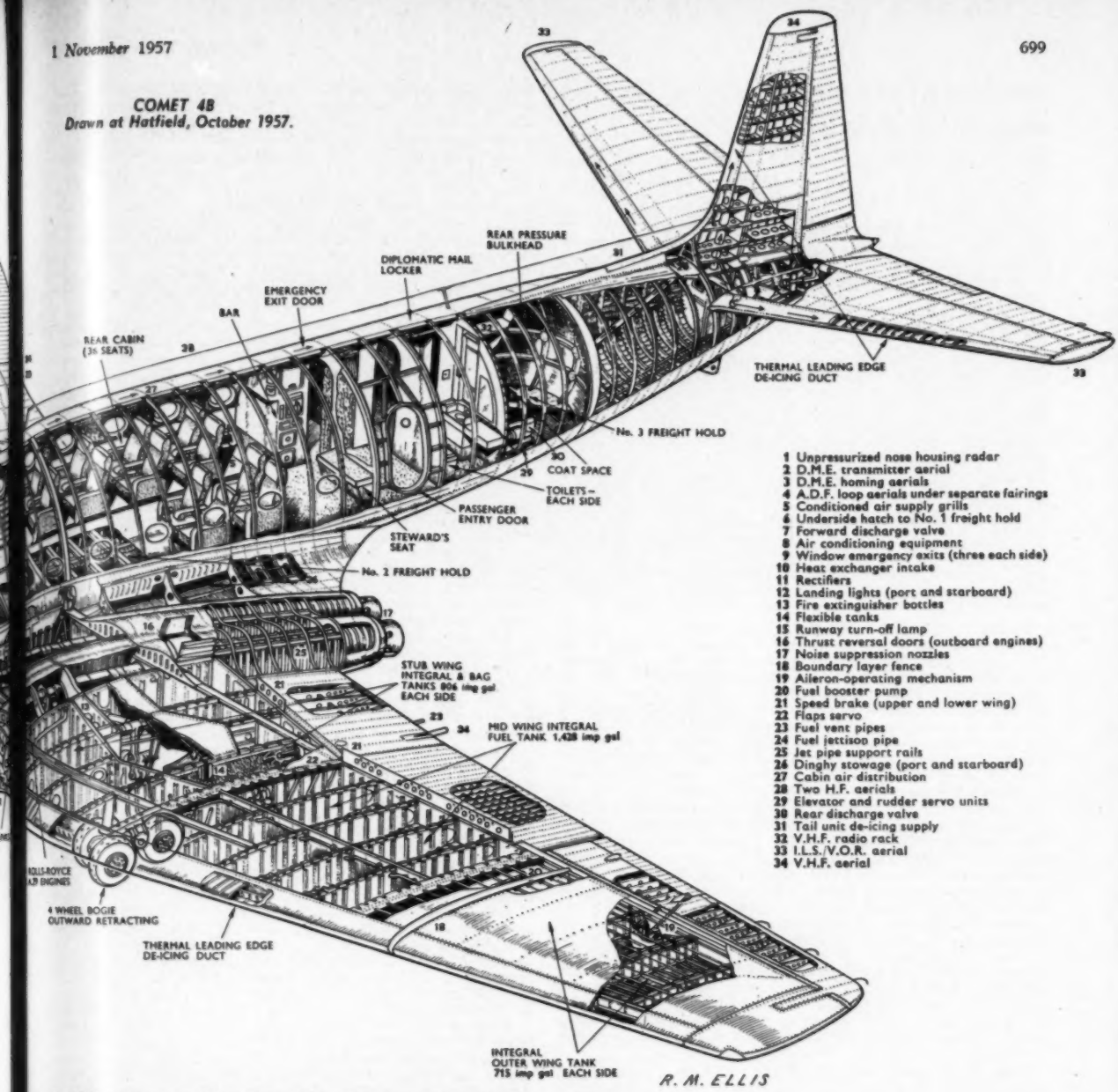
SYSTEMS **Flying Controls** The flying control system is mass-balanced and fully power-operated hydraulically. A q-feel device provides artificial feel proportional to air speed in the elevator circuit.

Operation of the control surfaces is by three duplicated hydraulic servo units, one for each circuit—i.e. elevators, ailerons, and rudder. Each hydraulic servo unit is controlled by duplicated valves operated by steel cables from the pilot's control column. The system is designed so that the control of elevators, ailerons and rudder is duplicated mechanically and triplicated hydraulically. Trim is accomplished by changing the datum of the control column's self-centring mechanism. Included in the elevator circuit is a gear-change unit to adjust elevator movement to suit low-speed and high-speed conditions.

The flaps are operated by three mechanically interconnected hydraulic power units. Speed brakes are operated by double quick-action hydraulic rams which can be applied at any speed up to aircraft limiting speed.

Fuel Total fuel capacity of the Comet 4 is 8,766 Imp. gal and of the 4B 7,890 Imp. gal. Each version has four flexible bag tanks in the centre section, two integral and one bag tank in each stub wing, and five integral tanks in each extension wing. The Comet 4 only has, in addition, two external nacelle tanks of 440 Imp. gal. capacity, one mounted on the leading edge of each wing.

COMET 4B
Drawn at Hatfield, October 1957.


REAR PRESSURE BULKHEAD
DIPLOMATIC MAIL LOCKER
EMERGENCY EXIT DOOR
BAR
REAR CABIN (36 SEATS)
THERMAL LEADING EDGE DE-ICING DUCT
No. 3 FREIGHT HOLD
COAT SPACE
TOILETS – EACH SIDE
PASSENGER ENTRY DOOR
STEWARD'S SEAT
No. 2 FREIGHT HOLD
STUB WING INTEGRAL & BAG TANKS 806 imp gal EACH SIDE
MID WING INTEGRAL FUEL TANK 1,428 imp gal
ROLLS-ROYCE AJ9 ENGINES
4 WHEEL BOGIE OUTWARD RETRACTING
THERMAL LEADING EDGE DE-ICING DUCT
INTEGRAL OUTER WING TANK 715 imp gal EACH SIDE
R. M. ELLIS

1 Unpressurized nose housing radar
2 D.M.E. transmitter aerial
3 D.M.E. homing aerials
4 A.D.F. loop aerials under separate fairings
5 Conditioned air supply grills
6 Underside hatch to No. 1 freight hold
7 Forward discharge valve
8 Air conditioning equipment
9 Window emergency exits (three each side)
10 Heat exchanger intake
11 Rectifiers
12 Landing lights (port and starboard)
13 Fire extinguisher bottles
14 Flexible tanks
15 Runway turn-off lamp
16 Thrust reversal doors (outboard engines)
17 Noise suppression nozzles
18 Boundary layer fence
19 Aileron-operating mechanism
20 Fuel booster pump
21 Speed brake (upper and lower wing)
22 Flaps servo
23 Fuel vent pipes
24 Fuel jettison pipe
25 Jet pipe support rails
26 Dinghy stowage (port and starboard)
27 Cabin air distribution
28 Two H.F. aerials
29 Elevator and rudder servo units
30 Rear discharge valve
31 Tail unit de-icing supply
32 V.H.F. radio rack
33 I.L.S./V.O.R. aerial
34 V.H.F. aerial

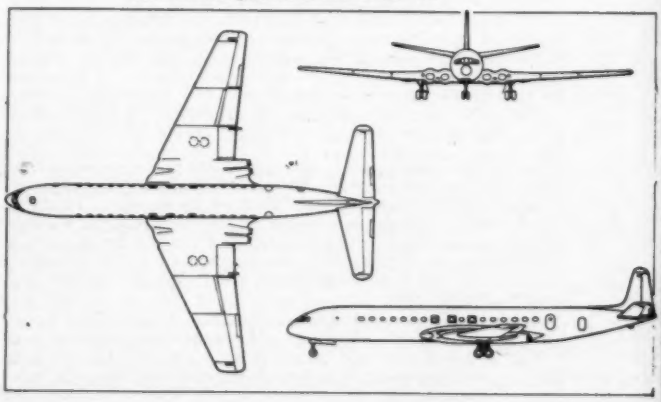
Refuelling is accomplished *via* under-wing connections on the port and starboard stub wings at a refuelling rate of about 200 Imp gal/min through each point. Supply to the engines is by duplicated immersed electric pumps. A jettisoning system discharges fuel from extension pipes on each wing trailing edge.

Cabin Air Supply for the cabin air system is tapped from the compressor of each engine; theoretically one engine is sufficient to maintain cabin pressure and conditioning to the required level. Heat exchangers and de Havilland turbine-expansion refrigerator units provide the necessary temperature control. Maximum differential cabin pressure is 8¾lb/sq in (8,000ft at 45,000ft). Discharge valves control pressure and dispose of used recirculated air, and relief valves limit maximum differential pressure and prevent negative pressure building up in the event of an abnormally rapid descent. A humidifier is incorporated; windows are protected from misting by chemical containers which dry the air before it enters the window sandwich. Pressure control from the cockpit is automatic, it being necessary only to preset the altitude at which it is required to start pressurizing.

De-icing Protection of the wing, tailplane and fin leading edges and engine air intakes against ice is accomplished by means of hot air tapped from the engine compressors. Windscreens and pitot heads are protected electrically.

Hydraulics The hydraulic system operates the flying controls, undercarriage, flaps, speed brakes, wheel brakes and nose-

General arrangement of the Comet 4B.



AIRLINERS OF THE WORLD

COMET 4 and 4B

wheel steering. Normal pressure is 2,500 lb/sq in. The system comprises four separate circuits, where necessary with independent reservoirs and hydraulic accumulators, with a colour code as follows:—

Green: Serves undercarriage retraction, nosewheel steering, flaps, speed brakes, and wheel brakes; provides stand-by power for the flying controls; and is supplied by two pumps, one driven by the port inner and the other by the starboard outer engine.

Blue: Serves primary flying controls only, and is supplied by two pumps, one driven by the starboard inner engine and the other by the port outer engine.

Red: Provides emergency operation of the undercarriage flaps and wheel-brakes through independent lines, being supplied by an electrically driven hydraulic pump. A hand pump in this circuit provides a final emergency method of lowering the undercarriage.

Yellow: Second emergency supply for the flying controls (operating the secondary servo unit rams through separate lines) supplied by an electrically driven pump.

Electrics Electrical power is supplied by four engine-driven 14kVA alternators, each with a continuous rectified output of 350 amp maintained at 28 V. Six 24 V, 25 amp-hr batteries are installed. Five of the batteries are connected in series with a switch for internal engine starting. Power distribution is from a single busbar which in the event of failure automatically splits into two parts, services being maintained by the good part. Inverter sets provide A.C. at 115v 400 c/s, 3-phase, for auxiliary power and at 26 V 400 c/s single-phase *via* transformers.

FLIGHT DECK Although it is unlikely that Comet operators will use five crew members, a typical arrangement of the control cabin provides for captain, first officer, engineer, radio officer, and navigator. The pilot's instruments are grouped into three main panels: flight panel, laid out in conformity with current flight instrument standards, for each pilot, with a panel in between on which are grouped the engine instruments. Between the two pilots is a floor-mounted control pedestal incorporating throttles, trimmers, flap control, speed brake control, undercarriage retraction and autopilot controls, and high-pressure and low-pressure engine fuel controls. The engineer has a station to himself with a comprehensive panel arranged system by system to permit full control and observation of the aircraft systems. The radio navigation station has a spacious chart table and generous stowage room.

The type of radio and radar equipment is variable according to requirements, and a wide flexibility of choice is available. H.F. communication is by either duplicated transmitters and tunable receivers, or by duplicated transceivers. V.H.F. communication is by duplicated transceivers or by duplicated transmitters with the receiver as a section of I.L.S./V.O.R. receiver. Duplicated A.D.F. is provided, and I.L.S. and V.O.R. equipment may be arranged to operate combined or as separate units; provision is also made for Loran and D.M.E. (1,000 Mc/s or 200 Mc/s), and an airborne search radar scanner is located in the nose. Aerials are of the suppressed type where possible, with the notable exception of the two H.F. line aerials.

PAYLOAD ACCOMMODATION The Comet's passenger cabin is in two parts: a forward cabin about 25ft in length (Comet 4) and about 31ft in length (Comet 4B). The rear cabin in both versions is about 30ft in length. The two portions of the cabin are separated by a structural bulkhead in line with the main wing spars. Width and headroom are constant at 9ft and 6½ft respectively. Chairs are mounted on 31.7in tracks permitting different arrangements to be achieved easily.

Passengers enter *via* a door on the aft port side measuring 56in by 30in. Seven emergency escape exits are provided in the Comet 4 and ten in the Comet 4B. Common to both versions are the emergency door opposite the main entry door, and the crew door. In addition, the Comet 4 has four removable window hatches and the Comet 4B has six removable window hatches. The Comet 4B has an escape hatch in the flight deck roof for the crew.

Each version has three freight holds, two under the floor, one forward of the centre section (160 cu ft Comet 4 and about 200 cu ft Comet 4B) and the other aft (230 cu ft each version). The third freight hold, varying in volumetric capacity according to the passenger accommodation provided, but with a maximum capacity of about 200 cu ft, is situated at the extreme aft end of the pressurized cabin and is accessible *via* its own freight door on the starboard side of the fuselage.

Comet 4 Layouts A typical first-class four-abreast layout accommodates 56-60 passengers. Alternative plans are available to seat 67 mixed-class and 76 tourist passengers. There is a wide choice, according to customer's requirements, regarding the location of lounges, galley, carry-on luggage compartments, and toilets. For example, the 56-seat first-class arrangement has four toilets each with a washroom; a galley (situated on either side of the aft starboard side emergency exit door) with a second galley at the forward end of the cabin just aft of the flight deck.

Comet 4B Layouts A typical first-class four-abreast arrangement seats 84. This does not include the accommodation provided in a luxurious lounge seating up to 8 people, which is designed to be installed in the most forward (and quietest) part of the cabin. Two toilets and a wardrobe and a galley are installed at the aft end of the cabin. The mixed-class arrangement accommodates 90 (40 first-class and 50 tourist) with three toilets and a galley and two wardrobes.. The all-tourist arrangement accommodates 99, mainly five abreast, and offers the facility of the eight-seat lounge—unique in a tourist airliner.

COMMERCIAL HISTORY The Comet formula was conceived in 1946, and applied to public service in May 1952. After the suspension of services in 1954, following the two Comet 1 accidents, and applying the new structural knowledge gained as a result, de Havilland concentrated upon the development of the Comet 4. This Rolls-Royce-powered version had twice the power and almost twice the capacity of the early Ghost-powered Comet 1. B.O.A.C. placed an order for 19 in February 1955.

In July 1956, a development of the Comet 4, the 4A, was announced. This new Comet version had been designed to the requirements of Capital Airlines of America, who ordered a fleet of ten for delivery starting in June 1959 (Capital also ordered four interim Comet 4s—to be returned when the 4A fleet had been built up—for delivery starting in November 1958 to permit the start of US domestic jet services in January 1959.) But Capital's Comet order was deferred in May of this year due to the airline's financial difficulties, and the 4A—a stepping stone between the 4 and the 4B—may now be considered extinct. If Capital reinstate their Comet order (notwithstanding recent reports from the U.S. that the Comet contract has in fact now been cancelled) the Comet 4B would be the version considered.

The first order for the 4B came from B.E.A., when in September last a fleet of six was ordered by the Corporation for delivery in 1959. The Corporation bought the 4B to maintain its competitive position until the projected "ideal" short-haul jet becomes available in 1963 (see Projects, page 722).

Although not part of the Comet's commercial history, except in the development it represents, it must be recorded that in June 1957 R.A.F. Transport Command's squadron of ten Comet 2s reached full strength, having been formed 12 months before. At the time of writing, a total of 7,000 hr had been flown on scheduled services to Australia and on special R.A.F. services all over the world.

In September last, B.O.A.C.'s Comet Unit resumed the operations suspended in 1954 when a Comet 2E, one of two now operated by the Corporation, started a high-intensity programme of daily flights between London and Beirut. Their purpose is to amass hours on the RA.29 engine of the Comet 4 and 4B; two are installed in each Comet 2E in the outboard positions. To date some 550 hr have been flown on these non-passenger development flights. It is intended to amass 10,000 RA.29 engine hours on 2Es, the prototype 3 and production 4s before services start in 1959. About 4,000 hr will have been recorded by Caravelles.

When B.O.A.C.'s Comet 4s enter service late next year they will have behind them quite a formidable record of development. Although specific target dates are not available, present plans are for the first production Comet 4 to fly "early in 1958," and for certification and delivery to be achieved by "the latter half" of 1958. B.O.A.C. plan to start services "before the end of 1958." The programme for the Comet 4B is for first flight in "late 1958," and for delivery to B.E.A. to begin "towards the end of 1959." B.E.A. expect to begin 4B services in 1960.

COMET 4

Four Rolls-Royce Avon RA.29 of 10,500 lb static thrust each

Dimensions: Span, 115ft; length, 111ft 6in; wing area, 2,121 sq ft; height, 28ft 6in.

Weights: Max. take-off weight, 152,500 lb; max. landing weight, 113,000 lb; max. zero fuel weight, 92,000 lb; equipped tare weight, 68,400 lb (58 seats), 68,685 lb (76 seats); capacity payload (58 seats first-class), 16,400 lb; capacity payload (76 seats tourist-class), 19,300 lb.

Performance: Take-off field length, sea level, standard conditions, max. weight, 6,380ft; landing field length, standard conditions, max. landing weight, without reverse thrust, 6,200ft; payload-range performance, see graph; typical cruising speed in standard condition, 506 m.p.h.; cruising altitude, long-range technique, 38,000 ft.

COMET 4B

Four Rolls-Royce Avon RA.29 of 10,500 lb static thrust each

Dimensions: Span, 107ft 10in; length, 118ft; wing area, 2,066 sq ft; height, 28ft 6in.

Weights: Max. take-off weight, 152,500 lb; max. landing weight, 113,000 lb; max. zero fuel weight, 98,500 lb; equipped tare weight, 73,755 lb (84 seats), 73,846 lb (99 seats), 73,789 lb (84 mixed-class seats); capacity payload, including freight (84 seats first-class), 19,680 lb, (99 seats tourist-class), 22,280 lb, (84 seats mixed-class), 21,624 lb.

Performance: Take-off field length, sea level, standard conditions, max. weight, 6,500ft; landing field length, standard conditions, max. landing weight, without reverse thrust, 6,260ft; payload-range performance, see graph; typical cruising speeds, 520 m.p.h. to 545 m.p.h. (depending on temperature); optimum cruising altitude (high-speed cruising technique), 23,500ft.

AIRLINERS OF THE WORLD

CONVAIR 880

Convair, Division of General Dynamics Corp., San Diego, California

LAST of the major American transport manufacturers to announce plans for a gas-turbine airliner, the Convair division of the General Dynamics Corporation have with this machine elected to aim at the important medium-range market (250 to 3,000 n.m. are quoted) with a four-jet aircraft weighing some 90 short tons and cruising at the very competitive speed of 615 m.p.h. When it was first revealed, in the early summer of last year, the project was designated Skylark 600; later it became Model 22, and it bore the name Golden Arrow. All these appellations have been superseded.

Virtually all responsibility for the development of the 880 is being borne by the Company's San Diego division, where by the spring of next year one million square feet will be devoted entirely to this aircraft. Design was virtually completed early this year—after very extensive detail alteration—and actual manufacture began with the machining of outer-wing spar booms in June. During October two special spar mills were installed, capable of handling the 80 and 90ft main spar booms, and Convair already have invested over $1m in CV-880 machine tools. The powerplant of the Convair jet is the General Electric CJ-805, the commercial version of the military J79; the 880 is the only aircraft to be designed around this engine.

AIRFRAME The configuration of the CV-880 follows very closely the classical layout of the larger Boeing and Douglas machines. The low-mounted wing has a sweep angle of 35 deg at 30 per cent chord, and on it are mounted the powerplants in widely spaced individual nacelles. The finely streamlined fuselage is of an oval section and the bogie main undercarriage units fold into boxes under the cabin floor. In the flying controls the aircraft differs from almost all other transports in that the ailerons are mounted much nearer to the roots of the wing than to the tips, and the horizontal tail incorporates an all-moving tailplane driven by a hydraulic motor and screw-jack.

Fail-safe principles have been employed throughout the structure. Although the wing is based on the same box-beam, plate-stringer structure as that of the Convair-Liner, it has three principal spars and distributes the load through a multiplicity of relatively small elements. At the root is an additional auxiliary spar which takes some of the chief undercarriage loads. Outboard of the outer engine pylons the centre wing spar is discontinued, fail-safe integrity being maintained by the fact that the trailing edge is unbroken by any movable surfaces.

Owing to its excellent fatigue-resistance 2024-T3 light alloy is widely employed in the airframe. It is used for the complete underside of the wing, including skin (roll-tapered from 0.08 to 0.25in), spar booms and extruded stringers. The upper skin is made of 7075-T6, with 7178-T6 used for most of the underlying members. The main undercarriage legs are hinged to the rear of the box beam and to a transverse member joined to the wing box and fuselage; the leg is designed to tear out without opening the integral tankage (which is described in the paragraph on the fuel system).

The leading edge contains two skins, between which is passed hot air for de-icing. Sandwich construction is widely used in the rear part of the wing and the movable surfaces in order to achieve good resistance to jet blast and noise. Each mainplane carries three sections of flap. Although double-slotted, the flaps run out on steel tracks in Fowler fashion, under the drive of spanwise tubes. Each flap section is of relatively short span.

Fuselage Like the DC-8 this has a cross-section formed from two arcs joined by flank-sections of very large radius; maximum height and width are respectively 149in and 138in. Most of the frames and stringers are Z-sections formed in 0.050in 7075-T6 alloy. A curious feature is the absence of stringers from a level below the windows up to between 40 and 15in of the upper centre-line. Skin is everywhere at least 0.063in, and maximum hoop-stress is as low as 8,460 lb/sq in.

Convair have followed Boeing's precept in having one small window between each pair of frames on each side, so that in most layouts there are two windows to each seat unit. Each window measures 12½in high by about 9in wide, and comprises three panes of stretched Plexiglas 55; any one pane can bear full pressure and the innermost is floated in rubber. Each window is carried in a single-piece aluminium-alloy forged frame supported solely by the heavy skin (up to 0.1in.). Tear-stopping details are incorporated in all frame/skin joints. At every frame is provided a transverse tie-beam across the fuselage on which is laid the metal-sandwich floor. A particularly ingenious feature is the final design of main door. Wider at the top than at the bottom, and of wedge section to dove-tail into its jamb, it is raised vertically on slotted tracks before being freed for normal outward opening.

A complete fuselage is to be tank tested. Already an outstanding fatigue life has been demonstrated during extensive testing of details, particularly after stress-concentration by saw-cuts or javelin-type guillotines.

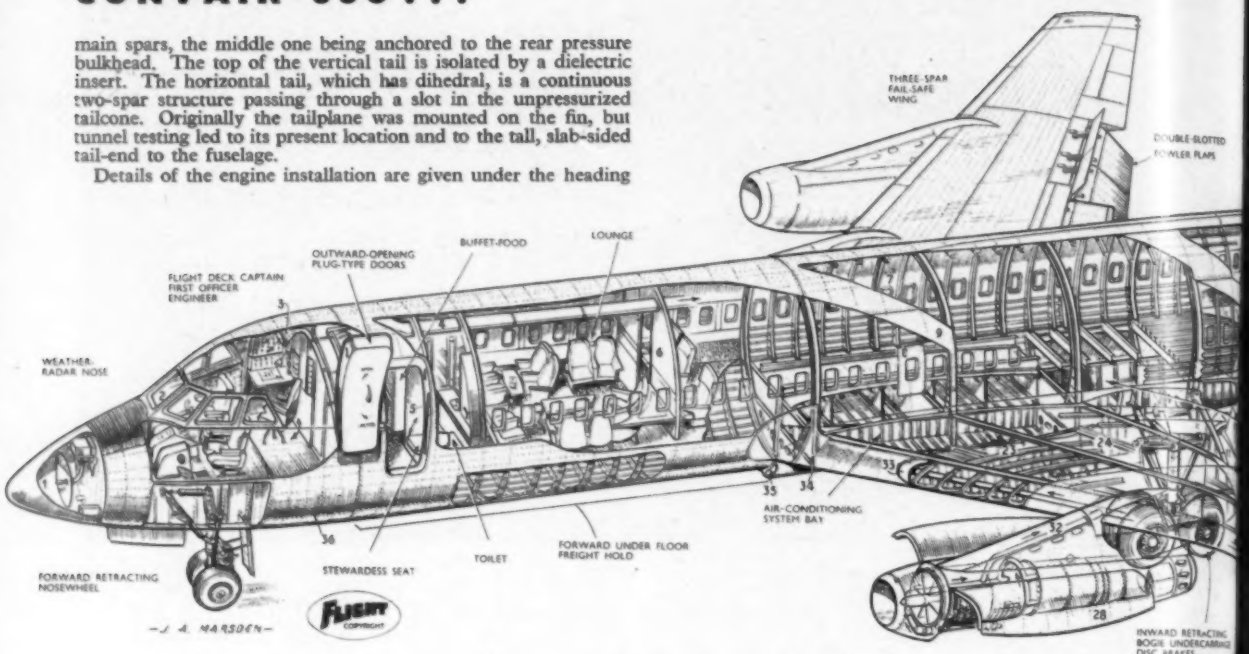
Empennage Design is fairly conventional. The fin has three

AIRLINERS OF THE WORLD

CONVAIR 880 . . .

main spars, the middle one being anchored to the rear pressure bulkhead. The top of the vertical tail is isolated by a dielectric insert. The horizontal tail, which has dihedral, is a continuous two-spar structure passing through a slot in the unpressurized tailcone. Originally the tailplane was mounted on the fin, but tunnel testing led to its present location and to the tall, slab-sided tail-end to the fuselage.

Details of the engine installation are given under the heading



"Powerplant." Each pylon is a fire-sealing structure attached to the front spar by two large single anchorages. Further attachments are provided at the leading edge and either the centre (inboard) or rear (outboard) spars. Like the undercarriage, the powerplant pylons are designed to tear off without impairing the integrity of the wing tankage.

Produced by the Cleveland Pneumatic Tool Co., the undercarriage comprises inward-folding four-wheel bogies and a forward-retracting nose gear. Each main unit has a vertical shock-strut, the outer cylinder of which is braced by fore-and-aft drag struts to the ends of the main trunnion beam to form a pin-jointed A-frame. The gear is locked in the down position by extension of the folding side stay to operate a trigger latch. Main tyres are 12.50 × 16in 20-ply nylon inflated to 115 lb/sq in. The nose unit has two wheels splined to a live floating axle, the tyres being 7.50 × 14 nylon 12-ply inflated to 80 lb/sq in. A constant-torque motor steers the lower leg through ±70 deg. A most unusual feature is the provision of brakes on the nose gear; all brakes are of the single-disc, multi-cylinder pattern.

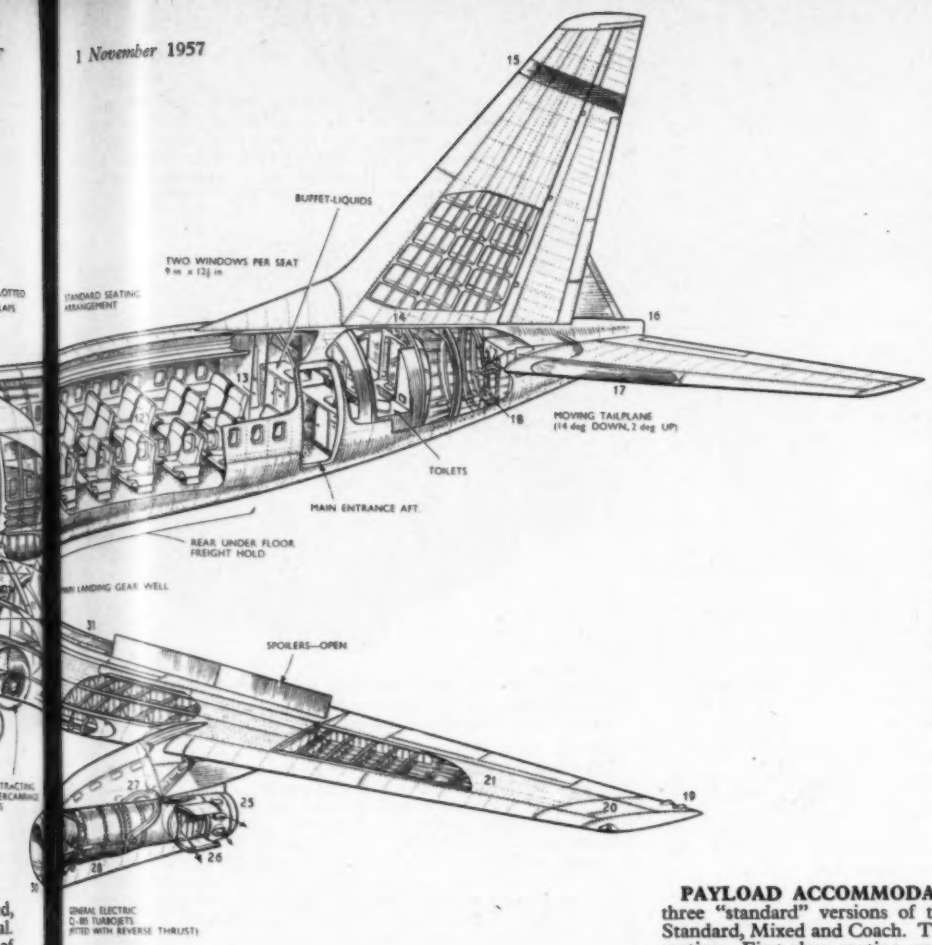
POWERPLANT Each engine is a General Electric CJ-805 single-shaft turbojet, rated at from 10,200 to over 11,800 lb depending on the development stage chosen (see *Flight*, July 26 last). The engine has a 17-stage compressor, of which the inlet guide vanes and the succeeding six stages of stator blading have variable incidence. All these rows are tied mechanically and governed by the basic hydro-mechanical control system. The front end of the engine is heated by compressor bleed air, and shaft power is extracted at the front end and taken along the underside to intermediate and rear boxes upon which can be mounted accessory units. Air is bled from all four powerplants to drive the cabin air compressor turbine, the Freon compressor and the condenser-cooling fans (all these are parts of the air-conditioning circuit).

Each powerplant is enclosed in a tight-fitting nacelle—by Rohr Aircraft—provided with very large doors on each side. Only about the first 40in of each cowling is of light alloy, titanium being used for the remainder. The actual intake lip is fabricated from stainless-steel sheet in order to withstand the arduous combination of impact and abrasion and high temperature (as a result of the anticing heating). The engine is supported at three points, the chief weight and thrust loads being absorbed by a steel forged hoop. The jet pipe is short and incorporates a General Electric TR-22 reverse-thrust deflector, ejecting on either side, and a noise-suppressing nozzle. Both the latter arrangements are similar in design to those developed by Rolls-Royce.

SYSTEMS **Flying Controls** Notwithstanding its high speed, the CV-880 has a control system which is almost entirely manual. The most novel part of the arrangement is the combination of inboard ailerons and spoilers for lateral control, as shown in the large drawing. Each aileron is a short-span "flipper-type" surface similar to that used on the Boeing 707 and it is actuated mechanically by means of an aerodynamic tab along its entire trailing edge. For control at the upper end of the speed range there are four sections of spoiler arranged ahead of the flaps (again like the 707) which are actuated hydraulically according to the commands of a "mixing box" which determines the manner in which lateral-control demands are shared between the spoilers and ailerons. All four spoiler sections can also be raised fully to behave as an air-brake for rapid let-downs, and the main undercarriage units can also be lowered at high indicated airspeed for a similar purpose. The rudder and elevators are manually operated by aerodynamic tabs and the latter is backed up by the variable-incidence tailplane, as previously noted.

Fuel In the standard Convair 880 all the fuel tankage is integral in the wing and entirely outside the fuselage. The port and starboard mainplanes each contain four tanks, namely: front and rear tanks from the start of dihedral near the root to outer inboard of the inner engines; from the latter rib to inboard of the engines; and from there to the tip. All tanks are sealed with Scotch-weld primer and tape (see Convair F-102, *Flight*, April 19, 1957). System capacity is about 8,968 Imp. gal., and there is a pair of 250 Imp. gal/min pressure-fuelling sockets in the underside of each of the intermediate tanks (i.e. a total of four under-wing connections). Three hydraulic-motor-driven jettison pumps in each wing feed a double nozzle at each wing tip.

Cabin Air Maximum pressure differential is 8.2 lb/sq in; sea-level pressure is held to 20,000ft, 6,000ft to 35,000ft and 8,500ft to 40,000ft. The air-conditioning system provides a complete change of air every 2½ min and maintains the interior at 75 deg F. System components are grouped axially along the underside of the fuselage beneath the wing centre-section, where they occupy a ventral bulge which also fairs-in the main undercarriage bay. According to customer preference, the refrigeration circuits may be driven electrically or pneumatically. In the former case the main A.C. supply drives the Freon compressors and cooling fans and the recirculating blower; in the latter, bleed air drives turbines coupled to the two former units (both of which are duplicated). In all cases, bleed air is used to drive the twin main compressors (fed from two ram intakes at the front of the air-system fairing), which in "pneumatic" 880s provide



1 Weather radar in bleed-air-heated radome
2 Nesa panels with air-jet slots
3 Main flight-deck air trunk
4 Main cabin air trunk (one each side)
5 Entrance-door locking slots
6 Non-structural bulkhead
7 Stringers absent over wide arc
8 Emergency exit panel each side
9 Skin thickness here 0.1in
10 Tear-stopping doubler
11 Undercarriage spar member
12 50in double seat unit with table
13 Service door and emergency exit.
14 Central spar joins pressure dome
15 Structural dielectric insert
16 Slab-sided rear fuselage end-cap
17 Electro-thermal sandwich de-icing
18 Hydraulic nuts running on screw-jack
19 Twin fuel jettison nozzle
20 Integral-tank venting outlet
21 Outboard tank
22 Intermediate tank
23 Forward inner tank
24 Aft inner tank
25 Noise-suppressing nozzle
26 Thrust-reverse doors each side
27 Steel horseshoe frame
28 Rohr-built titanium nacelle
29 Aluminium-alloy section
30 Stainless-steel lip
31 Flipper-type aileron
32 Bleed-air ducting
33 De-icing air space between skins
34 Dihedral of wing proper outboard of root
35 Ram intake to cabin air system each side
36 Electronics bay beneath floor

ground air supply and heating. In "electric" machines this is done by the recirculating fans and resistance heaters. In both versions, ground cooling is by the fans and Freon system.

De-icing The leading edge of the wing is heated by air bled from the engine compressors. As already noted, there are inner and outer skins over this entire region, and the thicker outer skin is chemically milled out to provide chordwise paths for the hot air, the full depth sections being aligned with the chordal structural members. Hot air is also used to antice the complete front end of the powerplant and nacelle. The leading edges of the fin and tailplane incorporate an unusual pattern of electro-thermal de-icing; the skin is composed of a three-layer sandwich, the outer surface of thin stainless-steel sheet being separated from the aluminium-alloy under-layer by a plastic sheet in which is moulded a network of wires. The pilots' windscreen panels are glass/vinyl/glass/vinyl/glass, the outermost layer being Nesa electrically heated panes. These panels are also provided with supersonic bleed-air jets to induce rain-shedding.

Electrics Three engine-driven 40-kVA alternators provide the main supply, at a constant 400 c/s frequency for 115 and 200v circuits. Wiring is provided for the installation of a fourth alternator. The complete system is fault-protected and fully paralleled. Four 50-amp transformer/rectifier units convert current from the main A.C. busses to feed a 28v D.C. system. The later is also served by a 24v battery.

Hydraulics Two engine-driven multi-plunger pumps feed a pair of 4,000 lb/sq in systems. This duplicated supply serves undercarriage retraction, wheel brakes, nose-gear steering, flaps, spoilers, jettison cocks, tailplane drive and other circuits.

FLIGHT DECK No particularly unconventional features distinguish the layout, which is representative of the very latest S.A.E. practice. Behind the two pilots is a third swivelling seat adjacent to a wall-panel on the starboard side. It is likely that the occupant of this seat will usually be a flight engineer. All normal electronics equipment is provided for, the majority of the sets being grouped under the cabin floor aft of the nosewheel bay. Weather radar is carried in the nose, ahead of the pressure bulkhead.

PAYLOAD ACCOMMODATION There are at present three "standard" versions of the CV-880, respectively labelled Standard, Mixed and Coach. These play upon two basic types of seating. First-class seating comprises a double seat unit 50in wide on each side, with a central 28in aisle. At the standard pitch of 38in this provides seating for 88, when the standard 12-seat lounge is inserted at the front of the aircraft. Coach seat-

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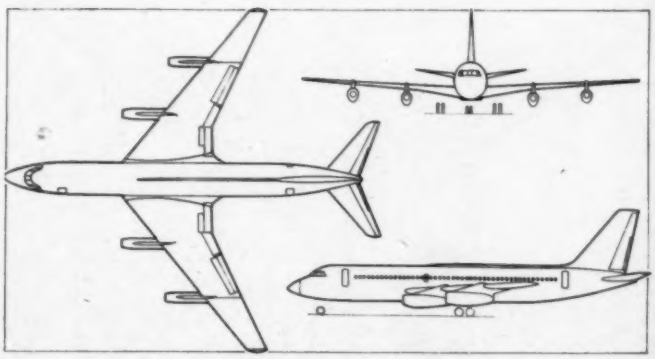
CONVAIR CV-880

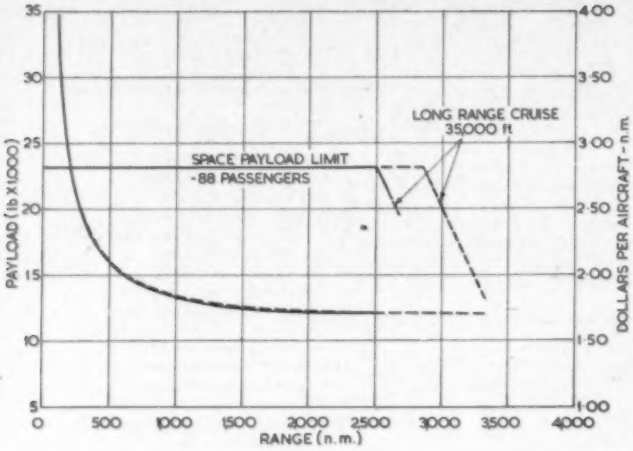
Four General Electric CJ-805-3 turbojets, each rated at 11,200 lb thrust, excluding losses from reverse-thrust and quiet nozzle.

Dimensions: Wing span, 120ft; root chord, 35ft 8.425in; gross area, 2,000 sq ft; dihedral, 7 deg; horizontal tail area, 395 sq ft; vertical tail area, 295 sq ft; overall length of aircraft, 129ft 4in; fuselage overall length, 124ft 2in; ruling exterior width, 11ft 6in; exterior height, 12ft 5in; height to tip of fin, 36ft 0.3in; track, 18ft 10.6in; wheelbase, 52ft 11in.

Weights (domestic version with 88 seats): Empty, 82,100 lb; basic operating weight, with 100 lb oil, 86,200 lb; space-limited payload (passengers, 14,520, baggage 3,520, freight 5,110), 23,150 lb; operating zero-fuel weight, 109,350 lb; maximum weight, 178,500 lb; structural payload, 30,800 lb; maximum landing weight, 132,800 lb; maximum zero-fuel weight, 117,000 lb.

Performance (CJ-805-3 engines, 178,500 lb, 100 per cent temp. accountability, obstacle height, 35ft): Take-off field length, 6,930ft at s.l., i.s.a.; landing field length (same conditions, flaps 50 deg, spoilers 60 deg), 6,000ft; range with capacity payload, 2,600 n.m. in l-r. cruise at 35,000ft in normal cruise configuration and thrust; block speed for 2,000 n.m. range in normal cruise for best cost, 445 kt (512 m.p.h.) with 42,000 lb block fuel; maximum cruising speed at 128,000 lb., 615 m.p.h.





Payload-range (upper) and direct operating cost for the overwater Convair 880. Full lines represent take-off weight of 178,000 lb, and 10,770 U.S. gal tankage; broken lines represent max. take-off weight of 186,500 lb, and 12,770 U.S. gal tankage. Reserves for 2 hr holding and 200 n.m. diversion (18,400 lb); still air; I.S.A. conditions. Similar reserves apply to the cost curves (1955 A.T.A. method).

AIRLINERS OF THE WORLD

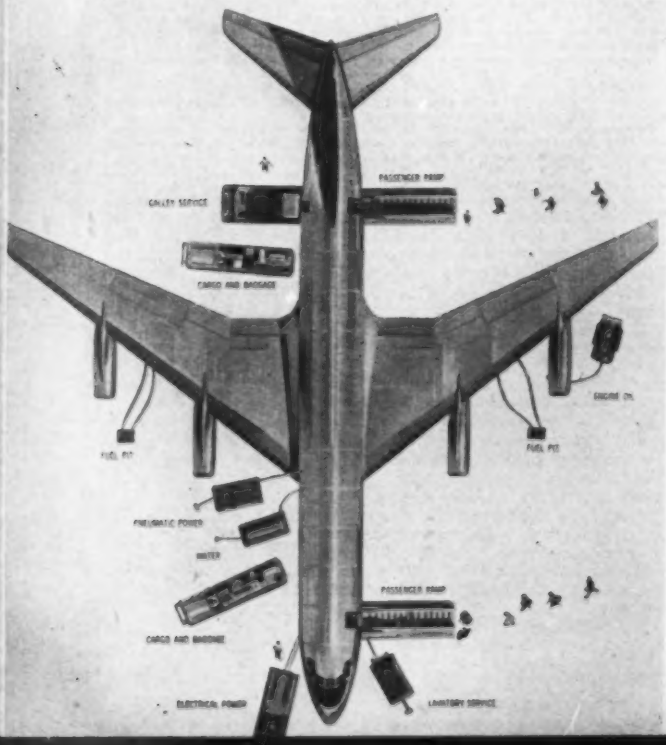
CONVAIR 880...

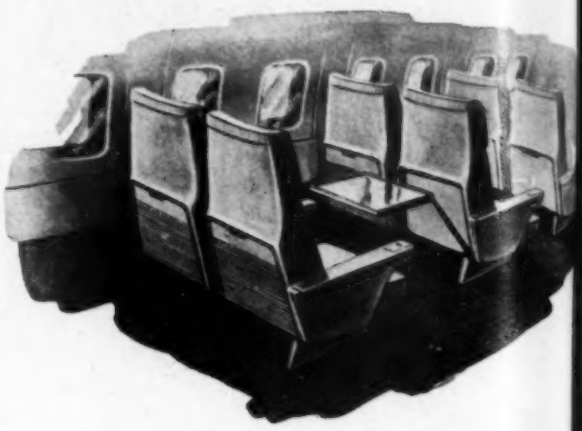
ing comprises rows of double (44in) and triple (65in) units, with a 19in aisle. When the lounge is dispensed with, this seating provides for 109 passengers.

In all versions the fore and aft ends of the usable space are similar. At the front is the main forward entrance, to port, flanked by coat stowage, a tip-up stewardess seat and toilet. Opposite, to starboard, is a service door/emergency exit flanked on each side by the food buffet. Aft is the rear main entrance, also to port, immediately to the rear of the back bulkhead of the cabin. On this bulkhead are mounted two further stewardess seats. To starboard is a second service door and to the rear are the liquid buffets and two toilets. Interior design has been assigned to The Harley Earl Corpn., and Dorothy Draper, Inc., is in charge of styling. All seating in the main cabin will be reclining and will be provided with a folding table (relatively rare in U.S. service); Hardman will supply most of the seat units. Except in the "all-coach" configuration, coat stowage is provided on both sides above the wing, to break up the apparent length of the cabin.

Under the floor is a total of 850 cu ft of usable volume for baggage and freight purposes. One hold is ahead of the wing, between the electric/electronics bay and the cabin-conditioning system. The larger hold is behind the wing. Special efforts have been made to reduce turn-round time, and this is now considered to be not more than 25 min. Air-stairs are not used, but standard passenger ramps are applicable to the aircraft.

The diagram depicts ground-servicing arrangements evolved for the 880. Although integral stairways are not incorporated, facilities for "turn-around" are such that the time should be reduced to about 25 minutes.





In common with the other American turbine-driven transports, new designs of seating and special interior apartments are being evolved for the CV-880. This artist's impression shows "standard" seating.

COMMERCIAL HISTORY As the latest of the American transport family to come on to the market, and a machine designed for a particularly difficult and keenly competitive field, the 880 has so far not sold very widely. Its announcement was coupled with the names of T.W.A. and Delta, and these major domestic operators have signed for 30 and 10 aircraft, respectively. In March the new Argentine operator Transcontinental, S.A., announced the purchase of four machines, under the auspices of California Eastern (who have a considerable interest in the S. American line). The latest firm order is for four aircraft placed earlier this year by REAL (Brazil). As we go to press there is still no confirmation of the large anticipated order by United, who are reported to have requested a fuselage extension to accommodate an additional row of seats.

Convair have erected a completely new mock-up building, costing $225,000, adjacent to Plant I in San Diego where the 880 work is concentrated. Here are to be found a full-scale mock-up which includes the fuselage, tail, port wing and port undercarriage and engine nacelles. Other mock-ups feature the passenger compartments and the 12-seat lounge. As stated at the outset, actual construction of the first 880 began this summer. Mating is due to take place next September and the machine is scheduled to fly in January 1959. Four aircraft will be used in the certification programme. First delivery (to T.W.A. for training) is scheduled for November of that year, and commercial services are due to be inaugurated in the spring of 1960 (certification is scheduled for May 1960), and all existing orders are to be fulfilled before December of that year. Convair state that there is no reason to doubt that this schedule will be met.

The CV-880 fuselage test-section below is currently being employed in the development of the cabin air-conditioning and sound-proofing, and it is being subjected to extremes of temperature and noise.

AIRLINERS OF THE WORLD

CARAVELLE

Société Nationale de Constructions Aéronautiques du Sud-Est, Paris

AFTER a remarkably smooth and short design and development period, the Caravelle is now fairly launched on its sales career. Contracts are in hand from Air France and S.A.S. with prospects of further orders from several other airlines. It is maturing at a moment when increasing interest is being shown in jet transports capable of operating short stages economically. The Caravelle was designed for just that purpose. Its average stage length in service will be about 500 miles.

The decision to build the Caravelle was taken in January 1952; a government contract was awarded to Sud-Est Aviation (which combined with Ouest-Aviation to become Sud-Aviation in 1957) in September 1952; metal was cut in April; the first machine was rolled out in April 1955; and the first flight was made on May 17, 1955.

In addition to the collaboration of Rolls-Royce, de Havilland's experience contributed considerably to the general design (ironically, it may now seem, since the Caravelle is a strong rival for the Comet in the short-medium-range jet market). Many British companies have supplied components, including Lockheed, Dunlop, Hobson, Venner, Teddington Controls, Self-Priming Pumps, Flight Refuelling, and Graviner.

AIRFRAME The circular-section fuselage is of conventional multi-stringer monocoque construction with a cylindrical section, 126in diameter and 53ft long, extending for nearly half the total fuselage length. Extensive use is made of spot-welding techniques and all joints are sealed with Araldite resin bond. The nose section is taken from the de Havilland Comet; there is a double-curvature portion between this and the cylinder which forms the bulk of the 6,120 cu ft pressurized fuselage. The fuselage contains 28 windows, 11 of which are inward-opening escape hatches; by the main entry door—unconventionally situated under the tail—and by a 78in by 69in freight door with an inset sliding crew-door forward on the port side.

Wing The design of the N.A.C.A. 651212 section wing was conditioned by the desire to provide a long-life structure with fail-safe characteristics. A three-spar torsion box forming an integral fuel tank is the basis of the structure. The top and bottom skins are taper-rolled and stiffened with quarter crescent-shaped ribs and stringers interspersed with pierced baffle ribs. Attached to the torsion box is the drooped leading-edge (the variable camber flap of the prototype has been discontinued on subsequent aircraft), two aileron sections and eight flap sections. Air brakes extend above and below the wing.

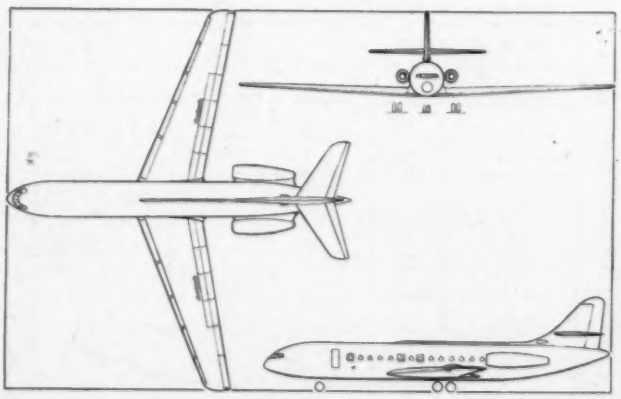
Undercarriage Of Hispano-Suiza manufacture, the main undercarriage comprises four-wheel bogies which retract partly into the wing and partly into the fuselage, and a twin-wheel nose undercarriage unit steered hydraulically through a range of 100 deg. Wheels, brakes and anti-skid units are supplied by Hispano, while the tyres, inflated to 96 lb/sq in, are supplied by Dunlop.

POWERPLANT The installation of the two Rolls-Royce Avon RA.29 (basically similar to the Comet 4 and 4B engine) in this position offers advantages which are worth restating: (1) the wing and flaps are aerodynamically clean from root to tip. (2) Fire risk is reduced by the separation of fuel and engines. (3) Cabin noise levels are low. (4) The change of air intake incidence with wing incidence is half that for wing-mounted engines. (5) Asymmetric thrust is negligible. (6) Thrust line is close to the centre of gravity, variations of thrust having little effect on longitudinal stability.

SYSTEMS **Flying Controls** The Caravelle shares with the Comet irreversible hydraulic servos for all surfaces. Proportional feel is also provided hydraulically, although the Caravelle has, in addition, base feel provided by pre-tensioned torsion bars. The Lockheed Servodyne valves are operated by cables from the duplicated wheels and pedals in the cockpit. A single Hobson "q-pot" device supplies controlled hydraulic pressure to all jacks according to dynamic pressure sensed at the starboard pitot head. A Lear autopilot is standard equipment.

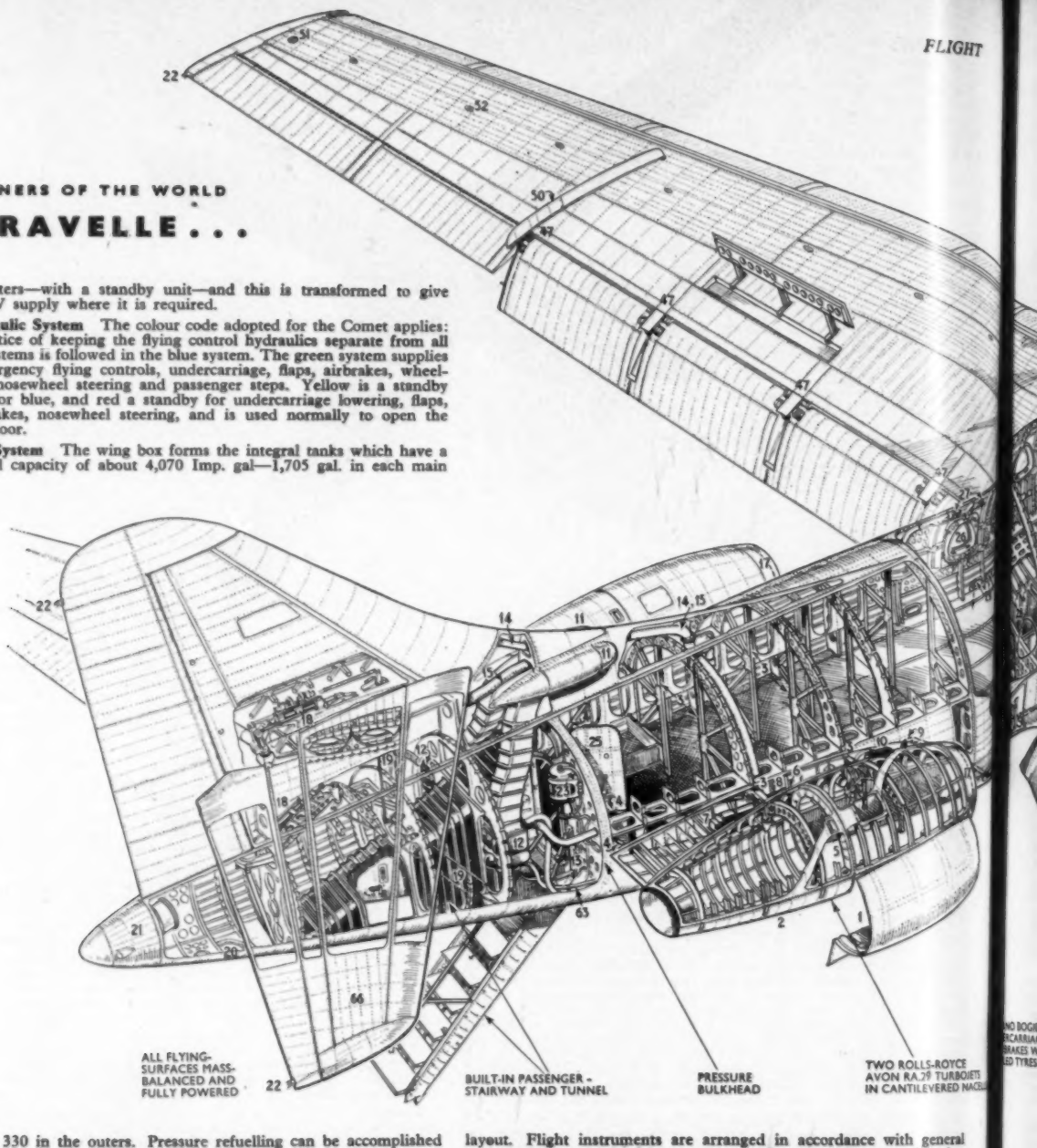
Cabin Air Tapped compressor-bleed air, passed through a heat exchanger, turbine expansion unit and water extractor, is used to pressurize the cabin to a differential pressure of 8.25 lb/sq in (8,000ft at 40,000ft). Cooling air is ducted from the two ram-air scoops at the base of the fin to the heat exchangers close to the engine. The Caravelle's cabin air system was developed in conjunction with the U.S. firm of AirResearch, who make much of the equipment.

Electrics There are three primary electrical circuits: a 28.5 V DC system; a 26 V 400 c/s AC system and 115 V 400 c/s AC system, with the structure used generally as the earth. Electrical power is supplied from a carbon-pile regulated 30 V DC generator on each engine with a continuously rated output of 375 amps, or an output limited to 30 min of 400 amps. All the 115 V AC current is supplied from a pair



AIRLINERS OF THE WORLD

CARAVELLE . . .


ALL FLYING-SURFACES MASS-BALANCED AND FULLY POWERED
BUILT-IN PASSENGER-STAIRWAY AND TUNNEL
PRESSURE BULKHEAD
TWO ROLLS-ROYCE AVON RA.29 TURBOJETS IN CANTILEVERED NACELLES

of inverters—with a standby unit—and this is transformed to give the 26 V supply where it is required.

Hydraulic System The colour code adopted for the Comet applies: the practice of keeping the flying control hydraulics separate from all other systems is followed in the blue system. The green system supplies the emergency flying controls, undercarriage, flaps, airbrakes, wheelbrakes, nosewheel steering and passenger steps. Yellow is a standby system for blue, and red a standby for undercarriage lowering, flaps, wheelbrakes, nosewheel steering, and is used normally to open the freight door.

Fuel System The wing box forms the integral tanks which have a total fuel capacity of about 4,070 Imp. gal—1,705 gal. in each main tank and 330 in the outers. Pressure refuelling can be accomplished in about 15 minutes through a single underwing point.

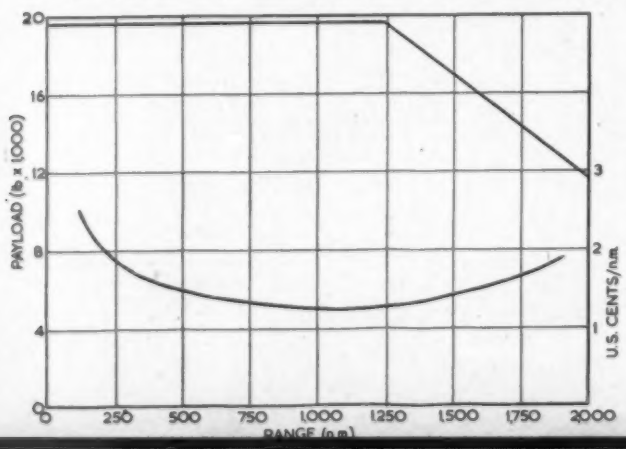
De-icing Thermal de-icing with air bled from the engine compressors is used in the leading edges of the wings and tail and for de-icing the engine air intakes. The pilots are supplied with an ethylene glycol hand pump for the windscreen panels, and dry air at cabin pressure—passing over silica-gel cartridges—is passed between the Perspex panels. The pitot heads are de-iced electrically.

FLIGHT DECK Since the nose portion of the Caravelle is identical with that of the Comet, the flight deck conforms closely in layout. Flight instruments are arranged in accordance with general commercial practice, and easy access to radio and engine controls makes the Caravelle a proposition for two-crew operation.

PAYLOAD ACCOMMODATION Typical layouts accomodate 80 tourist passengers five abreast, or 64 first class passengers. All the seats are mounted on to rails with a 31.7in track width for quick adjustment. In line with the needs of airlines with traffic fluctuations, the Caravelle has useful cargo accommodation. The total capacity is 608 cu ft distributed among two upper rear compartments aft of the passenger cabin (300 cu ft); an underfloor rear hold of 96 cu ft capacity; and a forward underfloor compartment of 212 cu ft capacity.

COMMERCIAL HISTORY The first order for Caravelles was placed by Air France in February 1956. They bought 12 and placed an option on a further 12. Delivery will start late in 1958 and should be completed by late 1960. Air France has already accumulated considerable proving experience with the second prototype, which they received in June 1956 for route trials and for scheduled freighting over their European and North African networks.

The past year has seen a heavy programme of demonstration and proving flights of the Caravelle, culminating in the successful tour of South America and the United States. In June of this year, an order of the first importance was placed by S.A.S., for six aircraft to be delivered between April and October 1959 and an option on 19 more. Deliveries to S.A.S. are to start in 1959.



Payload range (upper) and direct operating cost (lower) for the Caravelle. The range curve is for maximum payload of 19,840 lb, with a 6,600 lb fuel reserve. The cost curve is to the A.T.A. method.

Approximate equipped price: £785,000.

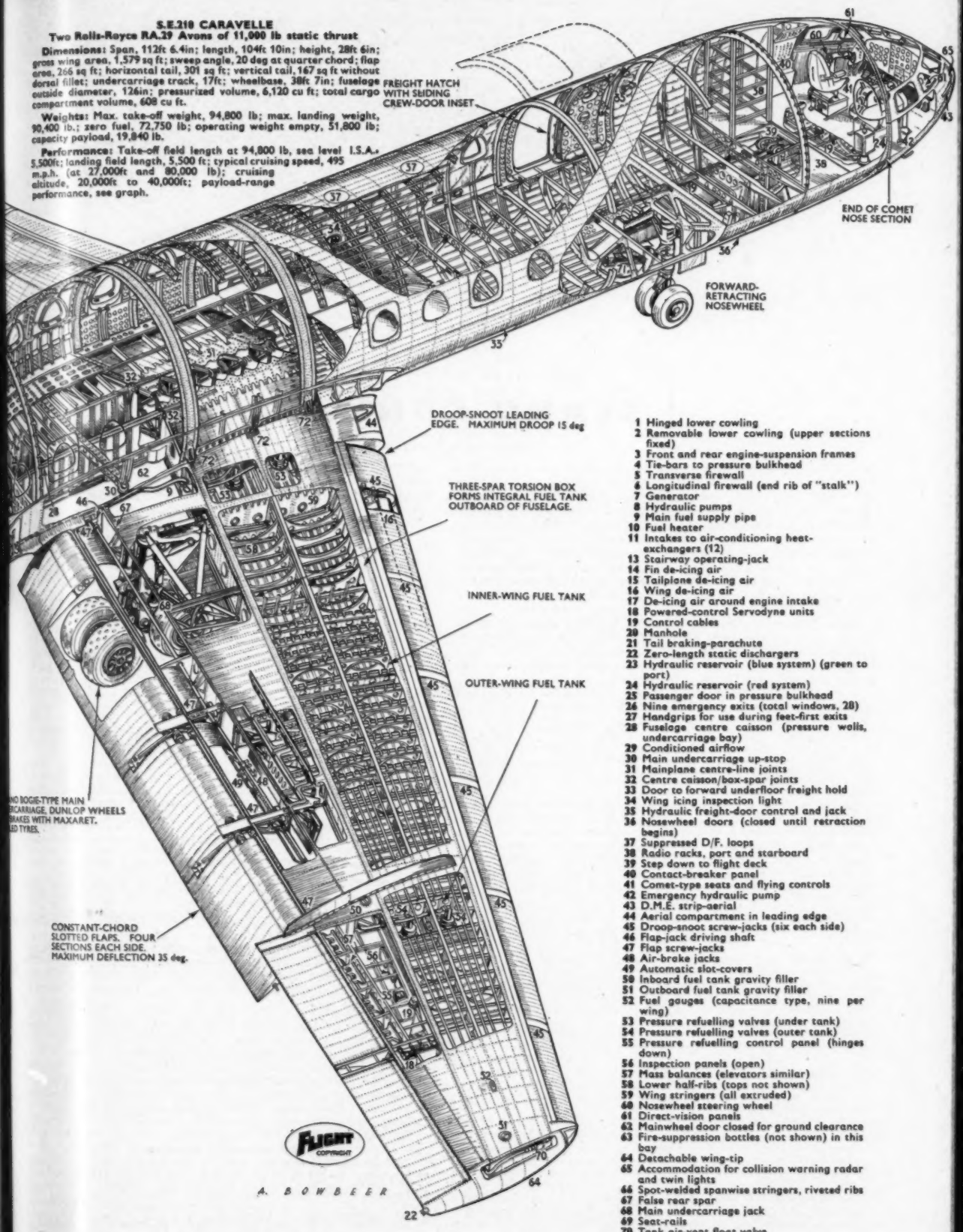
S.E.210 CARAVELLE

Two Rolls-Royce RA.29 Avons of 11,000 lb static thrust

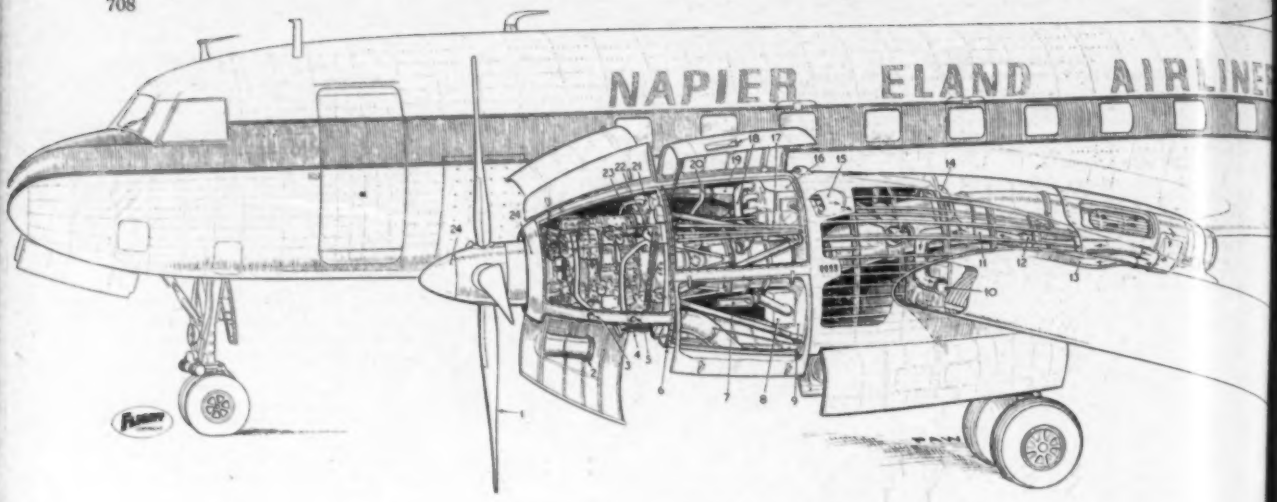
Dimensions: Span, 112ft 6.4in; length, 104ft 10in; height, 28ft 6in; gross wing area, 1,579 sq ft; sweep angle, 20 deg at quarter chord; flap area, 266 sq ft; horizontal tail, 301 sq ft; vertical tail, 167 sq ft without dorsal fillet; undercarriage track, 17ft; wheelbase, 38ft 7in; fuselage outside diameter, 126in; pressurized volume, 6,120 cu ft; total cargo compartment volume, 608 cu ft.

Weights: Max. take-off weight, 94,800 lb; max. landing weight, 90,400 lb.; zero fuel, 72,750 lb; operating weight empty, 51,800 lb; capacity payload, 19,840 lb.

Performance: Take-off field length at 94,800 lb, sea level I.S.A., 5,500ft; landing field length, 5,500 ft; typical cruising speed, 495 m.p.h. (at 27,000ft and 80,000 lb); cruising altitude, 20,000ft to 40,000ft; payload-range performance, see graph.


FREIGHT HATCH WITH SLIDING CREW-DOOR INSET
END OF COMET NOSE SECTION
FORWARD-RETRACTING NOSEWHEEL
DROOP-SNOOT LEADING EDGE. MAXIMUM DROOP 15 deg
THREE-SPAR TORSION BOX FORMS INTEGRAL FUEL TANK OUTBOARD OF FUSELAGE.
INNER-WING FUEL TANK
OUTER-WING FUEL TANK
NO BOGIE-TYPE MAIN CARRIAGE, DUNLOP WHEELS BRAKES WITH MAXARET. ED TYRES.
CONSTANT-CHORD SLOTTED FLAPS. FOUR SECTIONS EACH SIDE. MAXIMUM DEFLECTION 35 deg.
FLIGHT COPYRIGHT
A. BOWDLER

1 Hinged lower cowling
2 Removable lower cowling (upper sections fixed)
3 Front and rear engine-suspension frames
4 Tie-bars to pressure bulkhead
5 Transverse firewall
6 Longitudinal firewall (end rib of "stalk")
7 Generator
8 Hydraulic pumps
9 Main fuel supply pipe
10 Fuel heater
11 Intakes to air-conditioning heat-exchangers (12)
13 Stairway operating-jack
14 Fin de-icing air
15 Tailplane de-icing air
16 Wing de-icing air
17 De-icing air around engine intake
18 Powered-control Servodyne units
19 Control cables
20 Manhole
21 Tail braking-parachute
22 Zero-length static dischargers
23 Hydraulic reservoir (blue system) (green to port)
24 Hydraulic reservoir (red system)
25 Passenger door in pressure bulkhead
26 Nine emergency exits (total windows, 28)
27 Handgrips for use during feet-first exits
28 Fuselage centre caisson (pressure walls, undercarriage bay)
29 Conditioned airflow
30 Main undercarriage up-stop
31 Mainplane centre-line joints
32 Centre caisson/box-spar joints
33 Door to forward underfloor freight hold
34 Wing icing inspection light
35 Hydraulic freight-door control and jack
36 Nosewheel doors (closed until retraction begins)
37 Suppressed D/F. loops
38 Radio racks, port and starboard
39 Step down to flight deck
40 Contact-breaker panel
41 Comet-type seats and flying controls
42 Emergency hydraulic pump
43 D.M.E. strip-aerial
44 Aerial compartment in leading edge
45 Droop-snoot screw-jacks (six each side)
46 Flap-jack driving shaft
47 Flap screw-jacks
48 Air-brake jacks
49 Automatic slot-covers
50 Inboard fuel tank gravity filler
51 Outboard fuel tank gravity filler
52 Fuel gauges (capacitance type, nine per wing)
53 Pressure refuelling valves (under tank)
54 Pressure refuelling valves (outer tank)
55 Pressure refuelling control panel (hinges down)
56 Inspection panels (open)
57 Mass balances (elevators similar)
58 Lower half-ribs (tops not shown)
59 Wing stringers (all extruded)
60 Nosewheel steering wheel
61 Direct-vision panels
62 Mainwheel door closed for ground clearance
63 Fire-suppression bottles (not shown) in this bay
64 Detachable wing-tip
65 Accommodation for collision warning radar and twin lights
66 Spot-welded spanwise stringers, riveted ribs
67 False rear spar
68 Main undercarriage jack
69 Seat-rails
70 Tank air-vent float valve
71 Nosewheel jack
72 Main-frame/box-spar joints



AIRLINERS OF THE WORLD

ELAND-CONVAIR

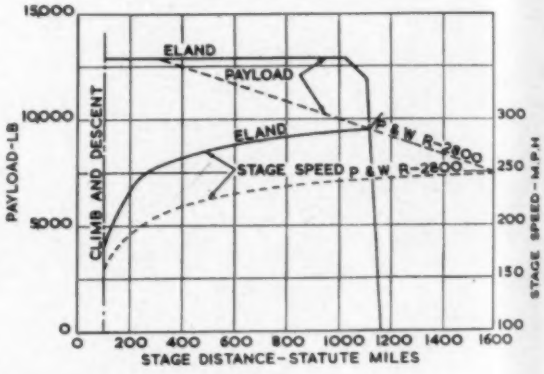
D. Napier and Son, Ltd., London, W.3.

EARLY in 1955, foreseeing that operators of successful piston-engined transports offered a promising market for conversion to turbine power, the Napier company bought a new production Convair 340 and adapted it—with help from Convair designers—to take Eland propeller-turbines. The installation was highly successful, and aroused great interest among operators of Convair 340s and 440s. In August of this year the first firm order—for the conversion of three aircraft—came from R.E.A.L. of Brazil.

Napier's present plans are to fly the converted prototype to the U.S.A. early in the New Year, where final C.A.A. certification tests will be undertaken. In the meantime, the Pacific Aeromotive Corporation of California are acting as Napier's agents, and will undertake conversion work.

Interest has also been shown in the Napier Eland conversion scheme by operators of DC-6Bs and Constellations (Painair do Brasil are considering the conversion of a number of their 749 Constellations.) There seems little doubt that, now an initial order has been placed, Napier will do steady business with operators of piston transports, who see in the Eland a means of renewing the life of their aircraft, and increasing their earning capacity and passenger appeal.

Conversion of the Convair 340 is achieved without major alterations to the airframe, as indicated by the drawing. The immediate advantage is to raise maximum permissible gross weight from 47,000 lb to 53,200 lb. The conversion gives the aircraft up to 55 m.p.h. more speed and increases range from 300 miles to 1,220 miles while carrying the Convair's maximum payload of 12,880 lb. Cost of the conversion is roughly £100,000.

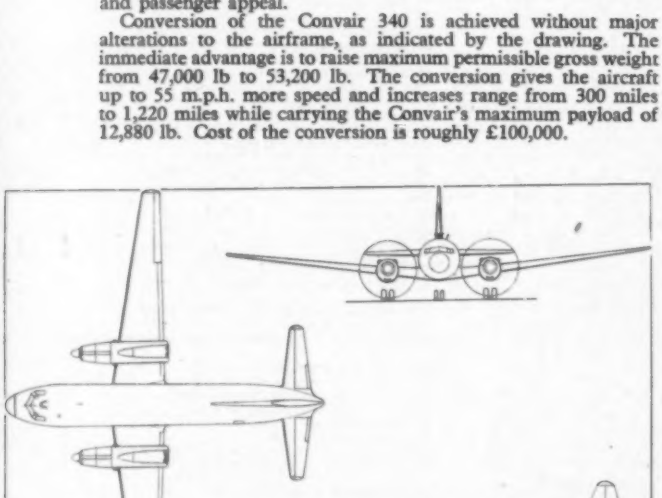


NAPIER ELAND-CONVAIR

Dimensions: Span, 105ft. 4in; length, 79ft 2in (81ft 6in with radar); height, 28ft. 1½in.; wing area, 920 sq ft.

Weights: Basic empty operating weight, 29,500 lb; max. payload, space limited, 44 passengers, freight and baggage, 12,880 lb; fuel tankage with max. payload, 10,556 lb.; max. gross weight, 53,200 lb; max. fuel tankage, 11,600 lb; max. structural landing weight, 50,670 lb; max. zero fuel weight, 44,000 lb.

Performance: C.A.R. field length, standard conditions, sea level, max. weight, 4,600 ft; landing field length at max. landing weight, 3,700ft; payload range performance, see graph; typical speed, see graph.

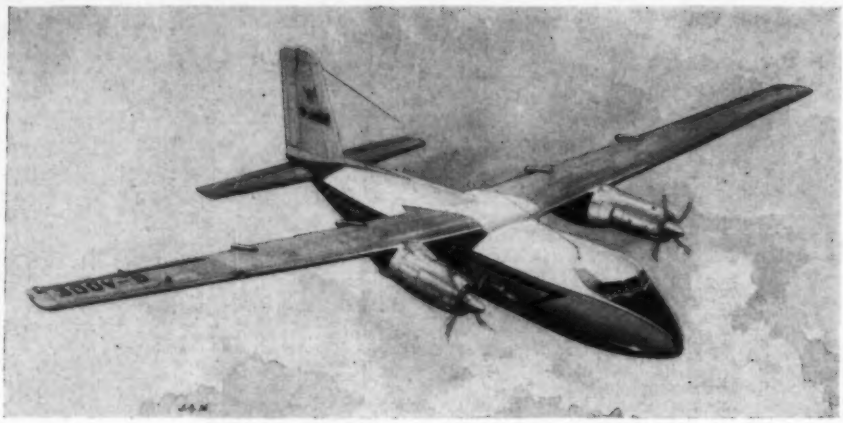


Napier estimate that a fleet of 20 converted Convairs, working stage lengths of 600 miles, with an annual utilization of 3,000 hours a year and a load factor of 65 per cent, could earn about £1 million more profit than a fleet of 20 piston-engined Convairs.

POWERPLANT The Napier Eland NEl.6 develops 3,000 s.h.p. (torque limited) at 12,500 r.p.m. Maximum continuous power is torque limited to 2,100 s.h.p. at 12,000 r.p.m. The Eland is a single-shaft single-spool turbine having a ten-stage axial-flow compressor and a three-stage reaction turbine driving a constant-speed propeller through an epicyclic reduction gear with a ratio of 0.0912:1. The propellers are de Havilland four-bladed, 13½ft units. The net dry weight of the engine is 1,625 lb, ± 2½ per cent.

Key to drawing in heading

(1) De Havilland 13½-ft Hydromatic propeller (2) Oil cooler air intake (3) Centrifugal breather (4) Oil cooler (5) Mounting-plate breather (6) Engine firewall (7) Air intake to battery-charging unit (port only) (8) Battery charging unit (9) Firewall (10) Outboard de-icing duct (11) Dall tube (12) Outboard heat-source valve (13) Cabin heating duct (14) Inboard de-icing duct (15) Air inlet to heat exchanger (16) Accessories gearbox housed in fireproof casing (17) Engine control rods (18) Alternator air intake pipe (19) Cable ducting (20) Turbine power breather (21) Oil tank (22) Engine controls (23) Drive to accessories gearbox (24) Napier "Spraymat" on spinner and engine air intake.



AIRLINERS OF THE WORLD

HERALD

Handley Page Ltd., Cricklewood, London

TWO versions of the Handley Page Herald are offered: the original piston-engined aircraft, with four Alvis Leonides Majors, and a new twin-turboprop variant with Rolls-Royce Darts. It is in the latter that airlines are showing most interest, and it is therefore mainly with the Dart Herald that the present description is concerned.

It should be recorded nevertheless that operators with airport problems are likely to find the piston-engined Herald a more attractive proposition; in the "hot and high" short-field conditions in which the Herald class of aeroplane is particularly likely to be used, the Alvis-engined Herald is substantially the better aeroplane.

Handley Page sum up the case for the Dart Herald as follows:

"Much effort has always been expended on the design and construction of aircraft for the world's better-known routes. There has been no airliner which has brought the same standards of flight comfort to the branch lines where low purchase cost and economic operation are even more important than on the prestige services. Hitherto those wishing to fly or send goods on a multitude of lesser—but equally important—airways, have had to be content with obsolete mainliners designed for different conditions or with small aircraft offering little passenger appeal.

"Handley Page realize that only those who operate civil aircraft on routes of this type know with certainty the qualities which such a transport must possess. Representatives of the company therefore made a painstaking field survey. Their enquiries took them to almost every airline in the world with short and medium length routes. It is doubtful whether any other aircraft company has ever made such a thorough investigation. The Herald branchliner is the airliner based on this investigation.

"For certain operations, such as those in remote areas, in very hot countries and in regions with small, high-altitude aerodromes—the piston-engined Herald is more suitable. The Dart-Herald, however, is some 80 m.p.h. faster and has a comparable take-off and landing performance in temperate regions where its greater speed and smoothness make it more attractive to operators and to passengers.

"Both versions of the Herald are similar structurally and both will come from the same production line. Their similarity will suit airlines with mixed operations. With them they will be able to have two-tier services: the four-engined Leonides-Herald will operate in particularly difficult conditions; the Dart-Herald will be ideal for the more sophisticated routes where extra speed is needed in order to attract passengers."

AIRFRAME Apart from the engine nacelles, integral tanks and fuselage-length, the structures of the Dart-Herald and the Alvis-Herald are identical.

Fuselage The fuselage is a section formed from various circular arcs, the two principal radii intersecting at two chine beams running longitudinally at the sides of the wide floor. The multiple frames are Z-sections above the floor and pressings below; to them are pop-riveted top-hat stringers to which the skin panels are spot-welded. The main frames aligned with the front and rear wing webs are box sections stressed to withstand belly landing loads. The main doors are to port with emergency exits on the opposite side. The main difference between the Dart-Herald and Leonides-Herald is an increase in fuselage length forward of the centre section amounting to 20in (to increase the distance between the crew-door and No. 1 propeller).

Wing The form of the wing structure is clearly shown in the cut-away drawing, which reveals such features as the corrugated sandwich web and upper and lower booms in the spar, which extends only across the centre section. Over this portion of the wing the skin also is a metal sandwich formed from a corrugated filler spot welded to inner and outer skins. The outer panels revert to a more conventional form of construction. An advantage of the sandwich skins in the centre section is that ribs are required only at the attachment points of the undercarriage, nacelle outer panels and fuselage. The outer wing of the Dart Herald, unlike the Alvis Herald, contains integral fuel tanks.

Tail The use of fluted skin makes possible a very simple internal structure, which is quite conventional and self-evident from the cut-away drawing.

Undercarriage The undercarriage is a product of Electro Hydraulics and comprises single shock struts carrying twin wheels, each unit retracting forwards hydraulically into a bay sealed by twin doors, closed by mechanical links to the leg. Tyre pressure is 60 lb/sq in. The nosewheels are hydraulically steered.

POWERPLANT The engines of the Dart Herald are Rolls-Royce Dart R.Da.7 (Mark 527) turboprops developing 2,100 e.h.p. each, driving Rotol four-bladed propellers of 12½ft diameter. The powerplant is similar to that evolved for the Viscount 810.

SYSTEMS **Flying Controls** Flying controls are operated manually through steel tension rods, cables and chains or push-pull rods. The flaps are hydraulically operated through a system of cables. Dual control columns are fitted in the cockpit. Each aileron carries a spring tab controlled by a torsion bar. The rudder incorporates a combined trim and spring tab which is operated through a torsion bar mechanism and by a mechanical jack for trimming. The port aileron incorporates a trim tab in addition to its spring tab. The starboard elevator has a trim tab and the port elevator has a balance tab.

Fuel System There are four flexible wing tanks and two integral wing tanks in the Dart Herald. The flexible tanks are fitted one behind the other in the wing centre section outboard of the nacelles: each forward tank holds about 180 Imp. gal and each aft tank about 160 Imp. gal. The integral tanks are in the root of each outer wing, and hold approximately 200 Imp. gal each. The total usable fuel carried in the Dart Herald is just over 1,050 Imp. gal.

Cabin Air System The cabin is pressurized to a differential of 3.35 lb/sq in. Temperature is controlled between 15 deg C and 21 deg C. Ram air enters intakes in the centre section outboard of each Dart nacelle and passes through two engine-driven Godfrey cabin blowers. From here the air is ducted to a silencer and thence to a heat exchanger for cooling. Final distribution into the cabin is *via* roof ducts.

A Normalair pressure controller in the cockpit controls cabin altitude through a discharge valve; an inwards relief valve and a safety valve are fitted also.

De-icing Hot air is supplied by two heat exchangers, one per Dart nacelle. Air drawn from an intake at the inboard side of each nacelle passes through the exchangers and is heated by the jet pipes; the heated air is then led to the wings and along the cabin roof to the tail unit. A liquid system for de-icing the windscreen is provided. Rotol propellers and air intakes are electrically de-iced.

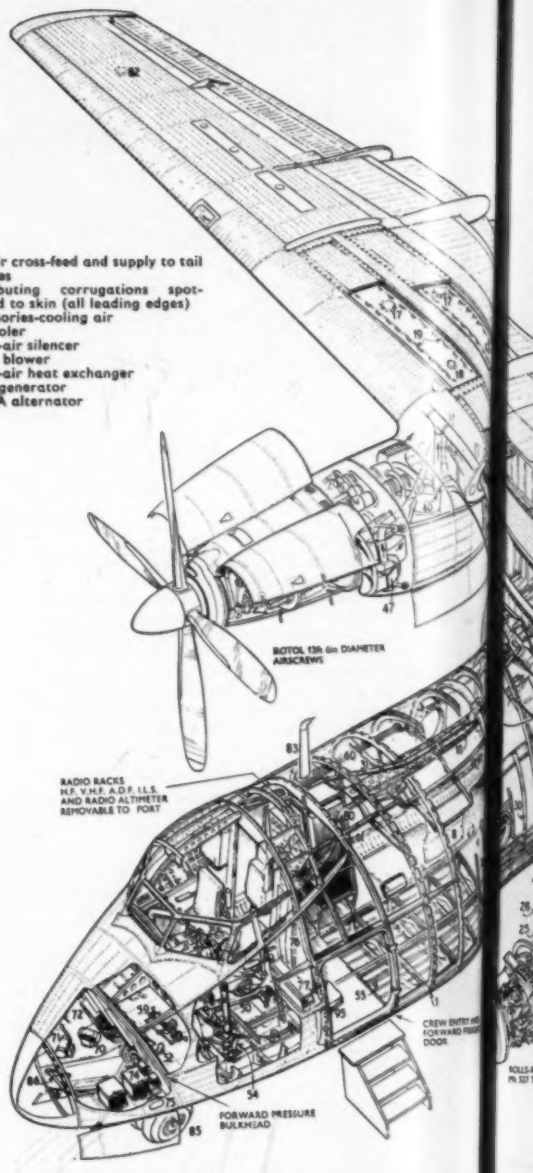
Hydraulics The hydraulic system operates at 3,000 lb/sq in and operates the undercarriage, flaps, steering and brakes. The system is supplied by two engine-driven pumps, one driven by each engine. A separate hydraulic system, supplied by an electrically driven pump, is used for lowering the undercarriage and flaps if the main system fails.

Electrics Electrical power is provided by two 28V 6kW D.C. generators, one driven by each engine. Three 24V 25 amp/hr batteries provide current for engine starting and two emergency services. Inverters provide A.C. current for instruments. The two D.C. generators give a

AIRLINERS OF THE WORLD

HERALD . . .

1 Transport joint
2 Top-hat-section stringers
3 Seat rails
4 Removable floor panels
5 Main wing-to-fuselage frames
6 Wing-to-fuselage pick-up
7 Notched frames
8 Hinged panels full length of roof
9 Rods carrying stringer stress through centre section
10 Main roof rail, carrying roof lights
11 Fin attachment
12 Corrugated skin
13 Tailplane attachment
14 Centrespar (floats through fuselage)
15 Corrugated-sandwich centre web
16 Corrugated-sandwich top and bottom booms
17 Tank fillers
18 Fuel contents unit (dipsticks stowed on freight door)
19 Cords lacing flexible tanks to top panels
20 Z-section outer wing stringers
21 Removable tips
22 De-icing air outlets
23 Outer wing joint
24 Undercarriage
25 Intake to heat exchanger for cabin air system
26 Intake to de-icing air heat exchanger (40)
27 Non-return valve in duct to cabin
28 Main roof duct
29 Cabin air distribution duct
30 Air piped to floor-level duct
31 Air to cockpit and windscreen de-misters
32 Cockpit air louvres
33 Mass flow control
34 Main discharge valve
35 Inwards relief and safety valves
36 Pipe from controller in cockpit
37 Individual punkah louvres
38 Fuel heater
39 Accessory-box drive
40 De-icing heat exchanger on tailpipe
41 Hot air cross-feed and supply to tail surfaces
42 Distributing corrugations spot-welded to skin (all leading edges)
43 Accessories-cooling air
44 Oil cooler
45 Cabin-air silencer
46 Cabin blower
47 Cabin-air heat exchanger
48 6 kW generator
49 7½ kVA alternator


ROTOL 13ft 6in DIAMETER AIRSCREWS
RADIO RACKS M.F. V.H.F. A.D.F. I.L.S. AND RADIO ALTIMETER REMOVABLE TO PORT
CREW ENTRY AND FORWARD FREIGHT DOOR
FORWARD PRESSURE BULKHEAD

wide margin of safety against failure since the maximum load is within the overload capacity of one generator. If one generator fails, the other is capable of carrying all essential, and some non-essential services.

FLIGHT DECK Two pilots form the flight crew for normal operations, but a radio operator's position can be fitted aft of the flight deck at the expense of some payload space. The layout of instruments and controls varies according to the requirements of operators as does that for the radio, navigational aids, and other equipment. A console between the pilots carries the engine and propeller controls, fuel controls, trimmers, flying control position indicators and selectors for the undercarriage, flaps, and autopilot.

PAYLOAD ACCOMMODATION The Dart Herald's cabin is 58ft long with a volume of 2,075 cu ft with a floor stressed to 150 lb/sq ft in the forward and rear freight areas, and 100 lb/sq ft elsewhere. There are two entrance doors. One on the port side towards the rear is an outward opening double door 5ft 4in high by 5ft 5in wide. Its forward section is used for passenger entry; both doors are opened for freight. The other door, 3ft 10in by 3ft, is also on the port side at the front of the cabin and hinges outwards and forwards. It acts as entry for the crew and for passenger or freight access to the forward cabin.

The standard cabin accommodation seats 36 passengers at a pitch of 38in. Maximum seating, at a reduced pitch, is 43. When both freight and passengers are carried the freight is stowed in the front of the cabin and a movable partition secludes passengers from freight.

COMMERCIAL HISTORY The first Alvis-engined Herald, G-AODE, flew on August 25, 1955. The second machine—more fully representative of the production aircraft—took the air just over a year later. The two aircraft have completed their programme of flight tests, mainly from Handley Page, Reading, and the bulk of certification work on the Alvis-engined Herald is now completed. Early interest in the Herald was strong (options on 35 aircraft were placed by four operators) but airlines subsequently became more and more influenced by world acceptance of the Rolls-Royce Dart. This led Handley Page, in May 1957, to offer the twin-Dart version. The first prototype had in the meantime been withdrawn from flight tests for conversion to Darts, and the present programme is for this converted aircraft to fly in early 1958, and for certification and production delivery of orders placed now, for either Leonides or Dart Heralds before the end of 1958.

HANDLEY PAGE DART HERALD

Two Rolls-Royce Dart RDa.7 Mark 527 turboprops of 2,100 e.h.p. each driving Rotol four-bladed, 12½ft propellers

Dimensions: Span, 94ft 9½in; length, 71ft 11in; height, 22ft 4in; wing area 886 sq ft; flaps, 81 sq ft each side; ailerons, 29.7 sq ft each; tailplane, 252 sq ft; elevator, 71.13 sq ft; fin and rudder (total), 193 sq ft; track, 22ft; wheelbase, 25ft 10in.

Weights: Basic operating weight, 36-seater, 22,269 lb; max. payload, 10,160 lb; zero fuel weight, 32,968 lb; max. take-off weight (also max. landing weight), 37,000 lb.

Performance: Take-off, balanced field length, sea level standard conditions, 3,700ft; tropical conditions (I.S.A.+15 deg C conditions), 3,950ft; sea level rate of climb, 1,580ft/min; rate of climb at 10,000ft, 1,030ft/min; cruising speed at 35,000 lb, standard conditions, at 17,400ft, 241 kt; stalling speed, max. weight, sea level standard conditions, 69 kt; landing distance from 50ft, 2,260ft; corresponding distance in I.S.A.+15 deg C conditions, 2,350ft.

†HANDLEY PAGE LEONIDES HERALD

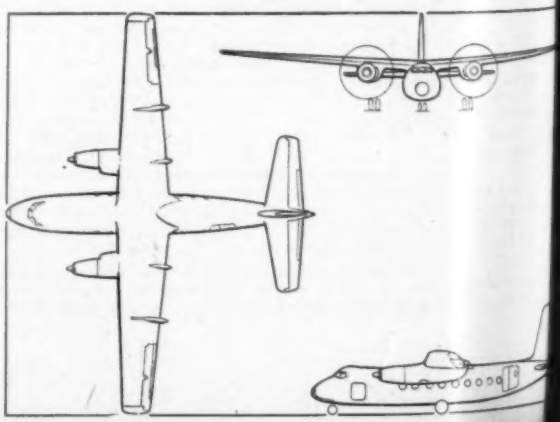
Four Alvis Leonides Major piston engines of 866 h.p. each driving de Havilland three-bladed, 11ft propellers

Dimensions: Length, 70ft 3in, otherwise as for Dart Herald.

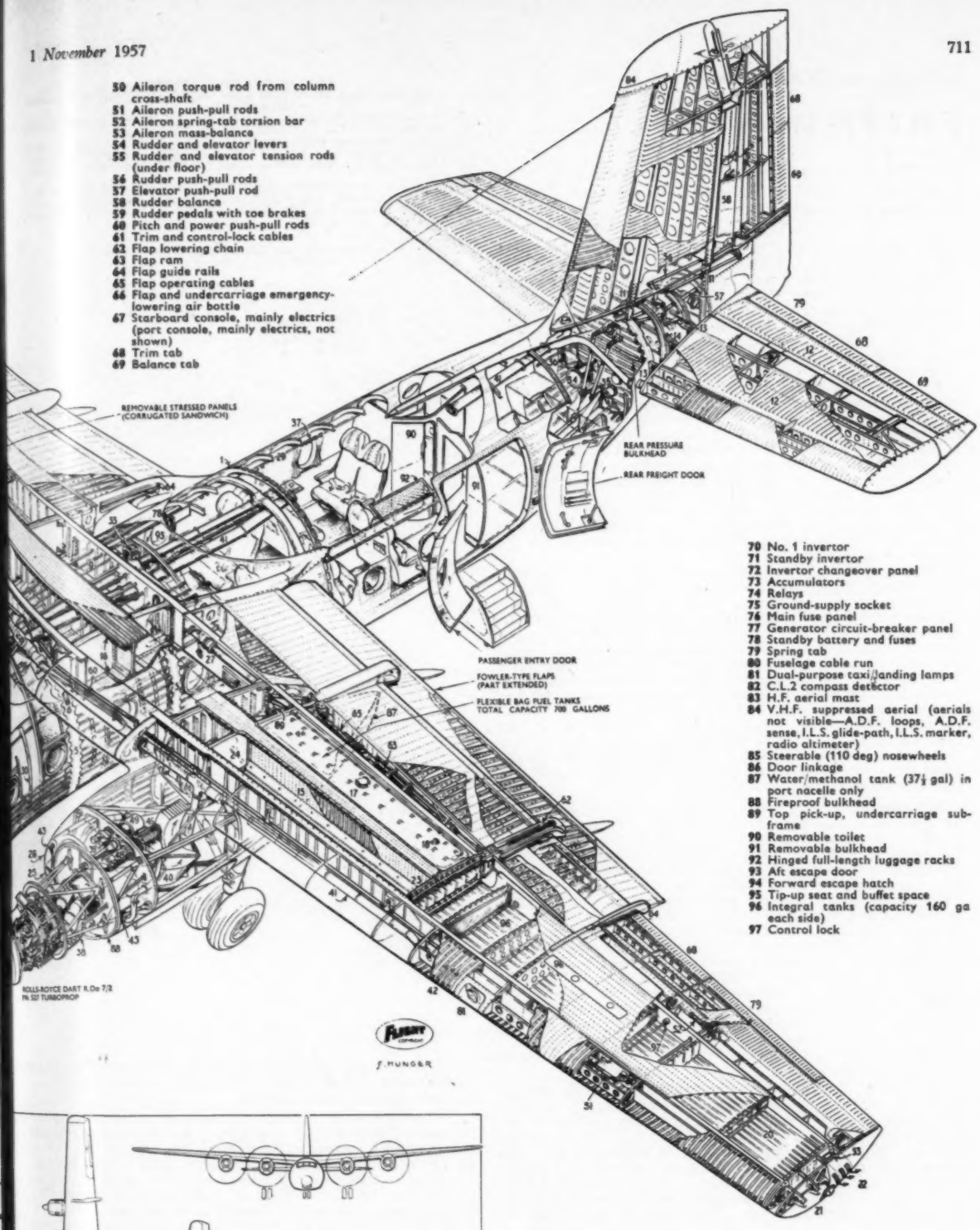
Weights: Basic operating weight, 36-seater, 25,241 lb; max. payload, 10,100 lb; zero-fuel weight, 25,880 lb; max. take-off weight (also max. landing weight), 37,500 lb.

Performance: Take-off, balanced field length, sea level standard conditions, 2,928ft; tropical conditions (I.S.A.+30 deg C), 2,714ft; sea level rate of climb, flaps and undercarriage up, 1,370ft/min; rate of climb rated power, at 7,150ft, 1,050ft/min; absolute ceiling, 21,600ft; level speed at 36,000 lb, standard conditions, max. weak mixture power, 10,000ft, 186 kt; corresponding speed at 13,350ft, 195 kt; stalling speed, max. weight, sea level standard conditions, 70 kt; landing distance from 50ft, 2,247ft; corresponding distance in tropical conditions, 2,430ft.

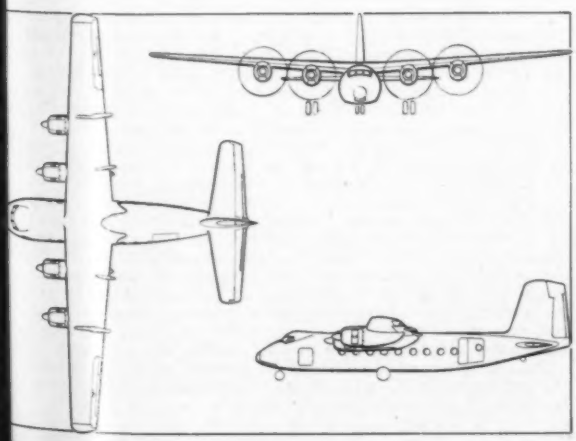
Below, Dart Herald; right, Leonides Herald. The direct operating cost curves (extreme right) are for the Dart Herald (S.B.A.C. method); broken line, 1,500 hr utilization, full lines 3,000 hr; A=I.F.R., B=I.F.R., C=V.F.R. Prices (furnished)=Dart Herald, £175,000, Leonides Herald, £145,000.

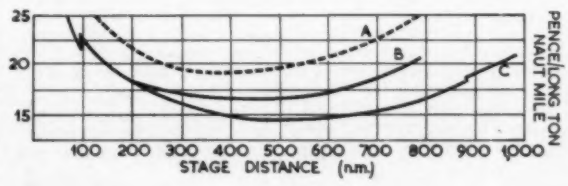


50 Aileron torque rod from column cross-shaft
51 Aileron push-pull rods
52 Aileron spring-tab torsion bar
53 Aileron mass-balance
54 Rudder and elevator levers
55 Rudder and elevator tension rods (under floor)
56 Rudder push-pull rods
57 Elevator push-pull rod
58 Rudder balance
59 Rudder pedals with toe brakes
60 Pitch and power push-pull rods
61 Trim and control-lock cables
62 Flap lowering chain
63 Flap ram
64 Flap guide rails
65 Flap operating cables
66 Flap and undercarriage emergency-lowering air bottle
67 Starboard console, mainly electrics (port console, mainly electrics, not shown)
68 Trim tab
69 Balance tab


REMOVABLE STRESSED PANELS (CORRUGATED SANDWICH)
REAR PRESSURE BULKHEAD
REAR FREIGHT DOOR
PASSENGER ENTRY DOOR
FOWLER-TYPE FLAPS (PART EXTENDED)
FLEXIBLE BAG FUEL TANKS TOTAL CAPACITY 700 GALLONS
ROLLS-ROYCE DART R.Da 7/2 Mk 527 TURBOPROP
FLIGHT
F. HUNGER

70 No. 1 invertor
71 Standby invertor
72 Invertor changeover panel
73 Accumulators
74 Relays
75 Ground-supply socket
76 Main fuse panel
77 Generator circuit-breaker panel
78 Standby battery and fuses
79 Spring tab
80 Fuselage cable run
81 Dual-purpose taxi/landing lamps
82 C.L.2 compass detector
83 H.F. aerial mast
84 V.H.F. suppressed aerial (aerials not visible—A.D.F. loops, A.D.F. sense, I.L.S. glide-path, I.L.S. marker, radio altimeter)
85 Steerable (110 deg) nosewheels
86 Door linkage
87 Water/methanol tank (37½ gal) in port nacelle only
88 Fireproof bulkhead
89 Top pick-up, undercarriage sub-frame
90 Removable toilet
91 Removable bulkhead
92 Hinged full-length luggage racks
93 Aft escape door
94 Forward escape hatch
95 Tip-up seat and buffet space
96 Integral tanks (capacity 160 ga each side)
97 Control lock





AIRLINERS OF THE WORLD

FRIENDSHIP

Royal Netherlands Aircraft Factories, Fokker, Amsterdam
U.S. Licensees: Fairchild Engine and Airplane Corp., Hagerstown, Maryland

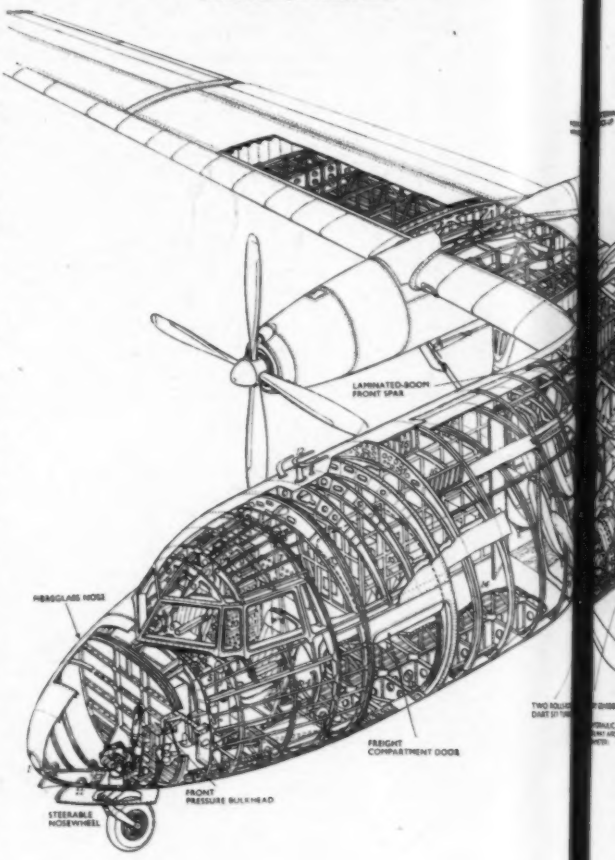
FOKKER F.27 FRIENDSHIP
Two Rolls-Royce Dart 511 of 1,740 e.p.h. each driving Rotol four-bladed, 12ft propellers*

Dimensions: Span, 95ft 2in; length, 75ft 9in; height, 27ft 6in; wing area, 754 sq ft; aspect ratio, 12.

Weights: Operating weight empty (32 seats), 22,000 lb; max. payload, 10,200 lb (32 passengers, catering and 4,792 lb of baggage and cargo); max. zero fuel weight, 32,200 lb; max. landing weight, 34,000 lb; max. take-off weight, 34,250 lb.

Performance (at 33,000 lb in standard conditions): Take-off balanced field length, sea level, 3,600ft; rate of climb, sea level, 1,480ft/min; 100ft/min ceiling, 34,000ft; cruising speed at 20,000ft, 13,600 r.p.m., 275 m.p.h.; landing field length, sea level, 2,900ft.

* A version with Dart 528s (1,960 e.h.p.) with improved performance, is offered also.



In a world air transport building industry which is dominated by a few big firms, it is remarkable that a small country like Holland should have come up with a transport as best-selling as the Fokker F.27 Friendship. This aeroplane has been greatly sought by that most needy, if the poorest, category of air transport—the branchline feeder routes of not very high traffic density which are still today largely flown by obsolete DC-3s and C-46s.

The Dutch firm of Fokker does not enjoy a big home market for this type of aircraft (K.L.M. operate a dozen DC-3s) but this fact, frequently bewailed by other European manufacturers, does not seem to have handicapped world-wide sales of the Friendship. It was a tremendous encouragement to Fokker when, last year, the Fairchild Engine and Airplane Corporation of America took up a licence to produce the Friendship for the U.S. local service airlines. The aircraft may now be considered as a joint marketing and production effort by the Dutch and American firms, with the British industry making a substantial contribution (amounting to about 30 per cent of total aircraft value) in the form of the Rolls-Royce powerplant, Rotol propellers, Dowty undercarriage and certain systems equipment. Fokker sum up the case for the Friendship as follows:—

"The many twin-engined commercial aircraft of pre-war design, often bought from war surplus dumps, though still faithfully serving short- and medium-range traffic, do not comply any more with the present-day requirements of single-engine performance, economy and speed. Take-off and landing performance are now dictated by stringent rules and regulations. Speed and economy are essentials for a profitable operation. All these factors have been taken into account in the conception and development of the Fokker F.27 Friendship. To cover the average demand, standard seating capacity has been fixed to 32 passengers and 4,800 lb of cargo with facilities for an increase to 36 or 40 passengers, without affecting the basic airframe. The combination of a payload of about four tons, a range variety of 300 to 1,000 miles, a high cruising speed and a low operating cost, make this propeller-turbine airliner a revenue-earning proposition which can be called attractive."

AIRFRAME The fuselage consists of a pressurized hull, designed for a differential pressure of 4.16 lb/sq in (8,000ft at 20,000ft). A large cargo door is included on the port forward side of the fuselage. Extensive use is made of Redux bonding in the attachment of stringers to skin. The high wing arrangement gives the advantage of low fuselage floor level for easy loading. The wing is of stressed skin construction comprising a centre section carrying the engine nacelles and detachable outer wing sections. The spars are of particular interest: the booms are bonded angle laminations, and the change in section is achieved by progressively reducing the number of laminations to combine strength with lightness and simplicity of construction. The outer wing is covered by a machine-tapered skin over two inboard sections, and integral fuel tanks are located between the front and rear spars. The construction of the tailplane and fin is conventional, as are all control surfaces. The main undercarriage is a Dowty unit with twin Dunlop wheels incorporating Maxaret brakes. Tyre pressure is 60 lb/sq in.

SYSTEMS **Flying Controls** Duplicated cockpit controls are fitted, and the control surfaces are conventionally operated by cables and push-pull rods, each surface having a servo-trim tab. A gust-lock lever in the cockpit allows only one engine at a time to be run to take-off r.p.m. with the flying controls locked. The flaps extend from fuselage to ailerons, and are of single-slotted compound type designed by Fokker. They extend for almost three-quarters of the total wing span, and are about one-third of the wing chord in depth. Maximum lift co-efficient for take-off is 3.7.

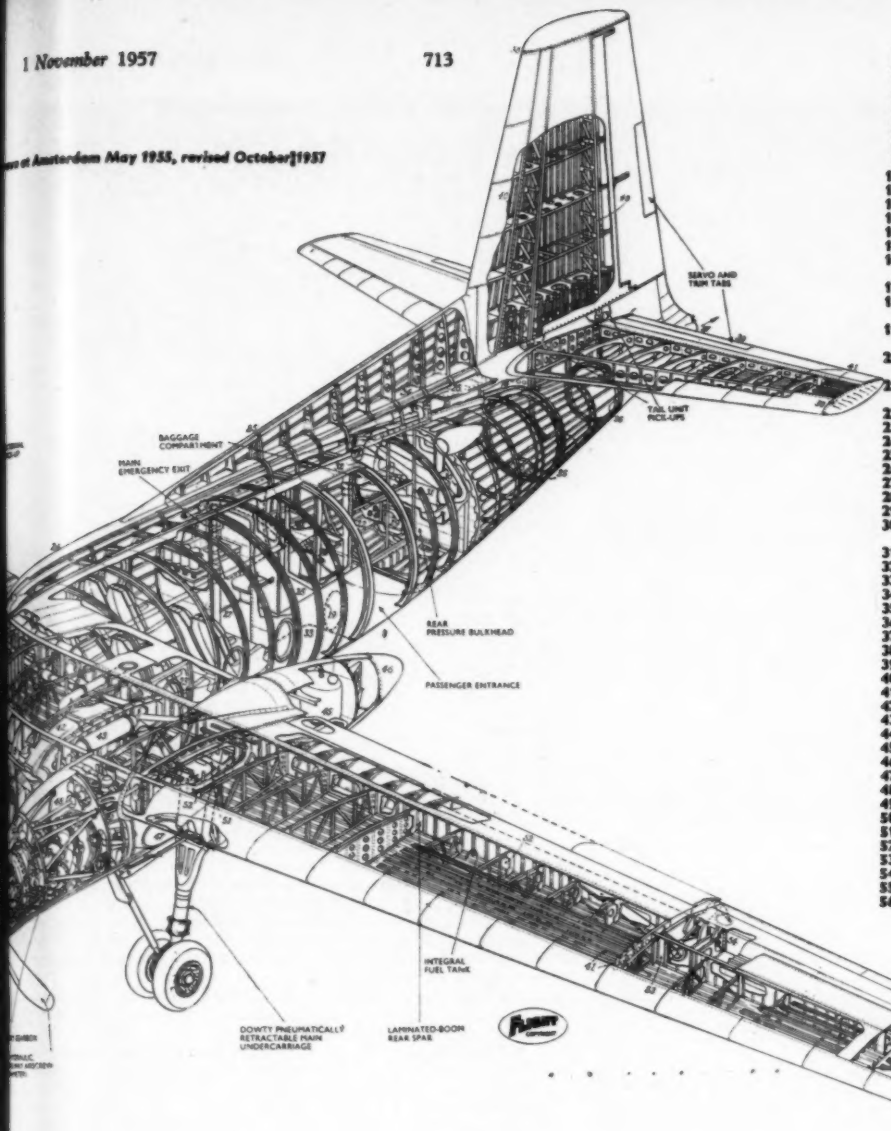
Cabin Air System The Friendship is pressurized to a maximum differential of 4.16 lb/sq in (8,000ft at 20,000ft). Two Godfrey cabin blowers, one driven by each engine, are the source of supply. The pressurized air enters through apertures under the luggage racks and through a separate duct to the cockpit, and is discharged *via* relief valves from an outlet aft of the rear pressure bulkhead. Air conditioning equipment includes a turbine-expansion cold-air unit located behind the rear pressure bulkhead, and automatic temperature control to maintain the cabin at 70 deg F in the lowest outside air temperatures.

Electrical System The electrical installation comprises two separate systems, (1) a 28V D.C. circuit, supplied by one engine-driven generator on each engine charging a 24 V battery, and, (2) an A.C. system using 115 V, 400 c/s main and auxiliary inverters run off normal aircraft D.C. supply, and two engine-driven alternators giving 208 V, 400 c/s.

Pneumatic System There are no hydraulics in the Friendship; pneumatic power was chosen to operate the undercarriage, brakes, and nosewheel steering. The system is powered by two Dunlop compressors, one driven by each engine, at 3,000 lb/sq in pressure. All actuators operate at 1,000 lb/sq in. The system is designed so that each half is independent in the event of failure. The undercarriage air supply is controlled by an electro-pneumatic valve which has a mechanical over-ride to guard against electrical failure; retraction time is 5 sec. Nosewheel steering is controlled by an infinitely variable valve coupled by lever and cable to the steering wheel on the left of the instrument panel (duplication for the first officer is optional). Power supply is cut off at a steering angle of 58 deg, and the self-centring device in the steering motor ensures that the whole assembly is centralized for retraction. The wheel-brakes are powered by the main storage system, with a small supplementary air bottle to maintain full pressure should the main air bottle pressure be low. The brakes are double-plate assemblies, and pneumatic Maxaret anti-skid units are fitted. Parking is achieved by depressing the toe-pedals and pulling a lock lever.

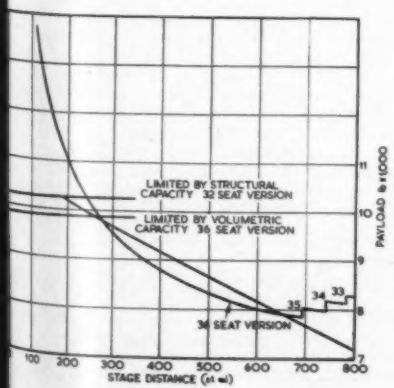
An emergency pneumatic system provides power for lowering the undercarriage and applying the brakes should there be a failure in the duplicated main supply system.

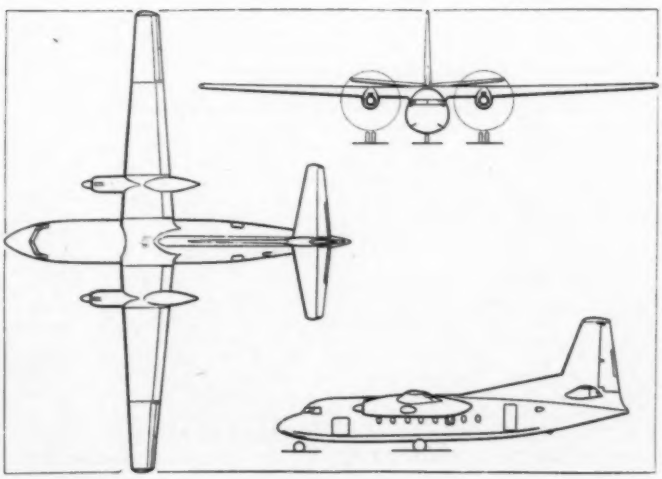
...at Amsterdam May 1955, revised October 1957

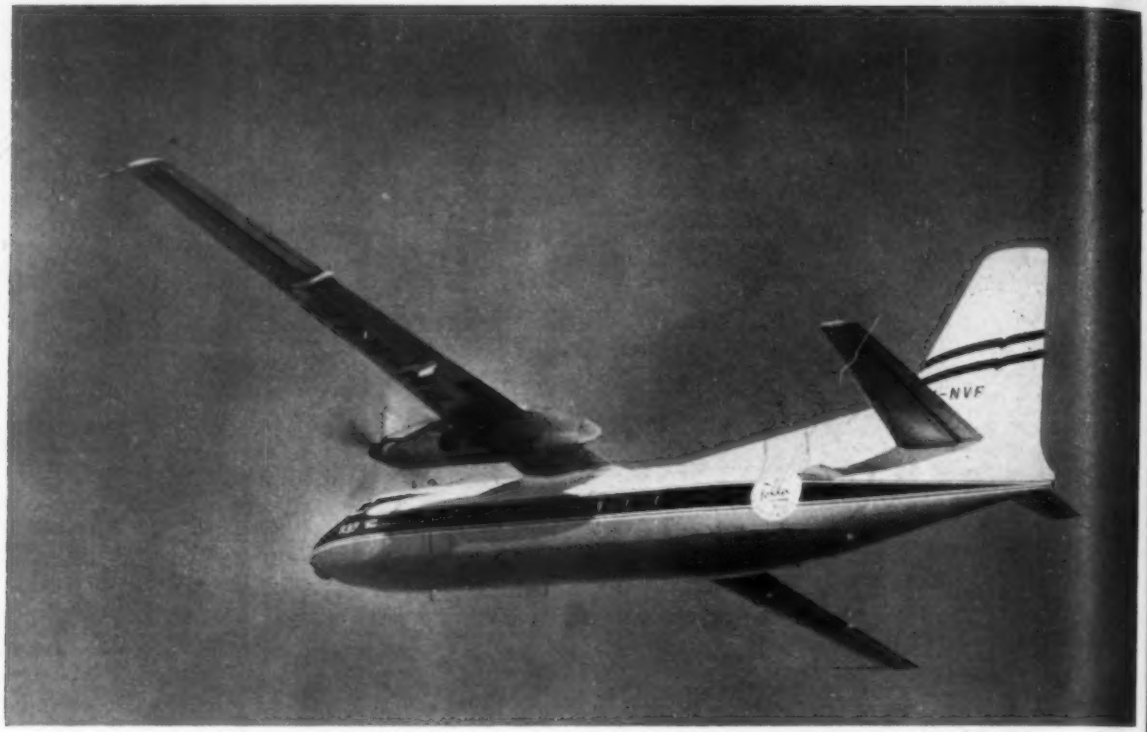


1 Taxying lamp
2 Direct-vision panels
3 Control column
4 Gust-lock lever
5 Central pedestal
6 Emergency undercarriage-lever
7 Circuit-breaker panel
8 Magnetic compass
9 Radio and electric panels
10 Radio compartment
11 Flight control-runs, behind bulkhead
12 V.O.R. aerial
13 Under-floor crash-member
14 Reinforced freight door
15 Freight stowage
16 Longitudinal stress-distribution members
17 Rear elliptical frame
18 Fokker/Kumbold rearward-facing seats
19 Extra windows available for extra seating
20 Pressure-skin fairing to centre section
21 Fibreglass leading-edge (centre section)
22 Honeycomb sandwich floor
23 Window/escape hatch
24 Dorsal control-run tunnel
25 Dorsal fin
26 Control-run inspection doors
27 Pantry
28 Toilet
29 Pressure relief valve
30 Main stiffening members for rear pressure bulkhead
31 Air-conditioning cooler
32 Ram air inlet (starboard side)
33 Space for coats
34 Pressurization duct
35 Marker aerial
36 Strengthened frames
37 Cabin-air outlet
38 Fibreglass leading-edge tip
39 Fibreglass trim-tabs
40 Lattice-type main spars
41 Stringers glued to skin
42 Anti-icing heat exchanger
43 Silencer (pressurization)
44 Wing/centre section joint
45 Water/methanol tank (Fibreglass)
46 Fibreglass tail fairing
47 Jet-pipe outlet
48 Steel firewall
49 Oil-cooler inlet
50 Oil-cooler outlet
51 Forged rib
52 Inboard and outboard tank-ribs
53 Outboard spar (51.25% chord)
54 Aileron operating mechanism
55 Sealed aileron
56 Fibreglass wing tip

...range curves and operating cost (S.B.A.C. ...) of the Friendship. Basic price: £190,000.







AIRLINERS OF THE WORLD

FRIENDSHIP . . .

Fuel System Total fuel capacity is 818 Imp. gal contained in integral wing-tanks. Port and starboard fuel systems are connected by a cross-feed line, and a small collector tank in each nacelle has a low-pressure fuel pump to reduce the amount of residual fuel. Refuelling is *via* either under-wing pressure connections or through over-wing filler caps.

De-icing The wings and engines are protected from ice-formation thermally, by exhaust-heated fresh air supplied to the leading edges. Tailplane de-icing is effected by electric heating elements. Operators have the alternative choice of pneumatic overshoes for de-icing.

Radio A typical radio installation, variable according to customers' requirements, comprises: Bendix or Collins V.H.F.; Collins glide-path and marker beacon receiver; Bendix A.D.F.; Standard Telephones V.H.F.; Collins H.F.; and Bendix intercom. Provision is made for the duplication of equipment.

POWERPLANT The engines are Rolls-Royce Dart R.Da.6 (Mark 511) of the type installed in Viscount 700D and Viscount 800 Series, developing 1,740 e.h.p. each and driving Rotol 12ft four-bladed propellers. The Friendship is now offered also with Dart R.Da.7s (Mark 528), developing 1,960 e.h.p.

The engine nacelles are in three sections: (1) nacelle centre-piece, having a fixed connection with the wing and containing the engine-mounting brackets, main undercarriage, and water/methanol tanks; (2) detachable powerplant complete with airscrew and cowling, and (3) detachable tail portion housing electrical equipment. At the forward end of the centre-piece is a fireproof bulkhead through which passes the outwards-inclined shrouded jet pipe. The Rotol auxiliary gearbox is mounted flat in a separate compartment behind the firewall, with the majority of accessories vertical.

FLIGHT DECK The flight deck accommodates two pilots, with provision for a supernumerary crew member if required. There are two conventional flight panels, one for each pilot, with engine instruments between. The central control pedestal incorporates throttles, fuel cocks, trimmers, flap levers and undercarriage selection. The overhead panel incorporates radio controls, engine starters and relight buttons and electrical switches. Layout of the flight deck was developed in close association with K.L.M., and is remarkable for its visibility, space and headroom.

PAYLOAD ACCOMMODATION The standard version of the Friendship carries 32 passengers. By moving the forward bulkhead, reducing the cargo space up forward, and by further reducing pantry space at the aft end of the cabin, seating can be increased to 36 or 40 maintaining the same 35in pitch. A lavatory-washroom is situated at the aft end, with a cargo compartment at the extreme aft end.

Originally the standard version of the Friendship—represented by the first prototype—accommodated 28 passengers in four-abreast seating (fuselage diameter is 8ft 10in) plus 280 cu ft of cargo space in the forward part of the fuselage. Towards the end of 1955, when the promise of increased Dart power became a reality, it was decided to stretch the fuselage 3ft forward on the wing, and to use the additional cabin space by installing an extra row of four seats. Cargo capacity remained the same, being accessible through a door on the port side (4ft × 3ft 7in, sliding inwards and upwards on rails), but passenger accommodation was thus increased from 28 to 32.

COMMERCIAL HISTORY The Friendship is Fokker's first airliner for 20 years, and can trace its ancestry to the famous Fokker airliners of the 'thirties such as the Trimotor F-7, F-10, F-12 and F-18 which were the standard equipment of many airlines, K.L.M. in particular. Fokker undertook the market research which resulted in the Friendship in 1951 and 1952. The decision to go ahead with the construction of a prototype was taken in the summer of 1952, and the first flight took place on November 24, 1955. By then the first order had been placed (two for K.L.M.), and in April 1956 the licence agreement with Fairchild—which had been the subject of negotiation for some time—was finally concluded.

The present Fokker and Fairchild Friendship order books, which significantly already include four airlines which have ordered Viscounts, stands at 107, and is as follows:—

Fokker-built: K.L.M., 2; Aer Lingus, 7 (late 1958); T.A.A., 6 (early 1959); Dutch Government, 1; "an Italian company," 1; Braathens, 3; Australian Government, 2; Iranian Oil, 2; Trabajos Aereos y Enlaces (Spain), 3 (spring 1959); Philippine Air Lines, 2 (late 1959); Sabena, 12; Belgian Air Force, 6.

Fairchild-built: West Coast Air Lines, 6 (March-October 1958); Mackey, 2 (March 1958); Frontier, 4 (October 1958); Bonanza, 3 (May-June 1958); Piedmont, 12 (April-October 1958); General Tire and Rubber, 1 (1958); Continental Can Co., 1 (1958); Quebecair, 2 (August-September 1959); other U.S. executive versions, 10; Aerovias Ecuatorianas, 1 (November 1958); Northern Consolidated, 3 (October 1958-April 1959); Southwest Airlines, 3 (September-October 1958); Wheeler Airlines (Quebec), 2 (February-March 1959); Avensa, 5 (July 1958-January 1959); Wien Alaska, 3 (February-April 1959); Butler Aviation, 1 (exec., 1959); Bank of Mexico, 1 (exec., 1959).

AIRLINERS OF THE WORLD

ACCOUNTANT

Aviation Traders (Engineering), Ltd., London W.1

BETWEEN 1950 and 1952, Aviation Traders carried out a comprehensive survey of aircraft, in both civil and military service, that were used to carry a combination of passengers and freight and could also be converted for ambulance, photographic or similar irregular or semi-regular use. Analysis of the results showed that, while the demands for aircraft with 40 seats and more and for 16 seats and less were being adequately met by new equipment, the intervening categories were still being catered for by the ubiquitous DC-3. There were, at that time, an estimated 6,000 DC-3s still in service in various capacities throughout the world.

Another category of aircraft for which a very large demand existed was also noted in the U.S. and Canada, where business flying was (and is) showing an upward trend that parallels the growth of the airlines. Here again, much of the equipment in use was converted war-surplus stock and there was apparently little being offered in the way of efficient and economical new executive aircraft to replace outdated equipment.

Numerical analysis showed that the majority of the world's aircraft could be classified in three ways: business aircraft, civil and military transports with a seating capacity of up to 28 seats, and those of up to 40 seats. The former two categories were greater numerically than the latter.

Aviation Traders decided that their design would attempt to fulfil the requirements of the first two categories, but would be capable of extension to meet the requirements of the third if that were needed. The Accountant, then, can be considered to fall into the broad category of a "DC-3 replacement" although only certain features of the Douglas design required perpetuation. For an executive aircraft the overruling essentials are felt by Aviation Traders to be long range and speed, and for feeder line aircraft low initial cost; low operating costs; simplicity of maintenance and versatility in the carriage of passengers or freight. The foregoing presupposes comfort, good field performance and high tip to ground propeller clearances in each application.

With this basis for their design philosophy, the company proceeded with the fundamental decision to use Rolls-Royce Dart turboprops—at a time when world-wide operating experience had not been accumulated and assured acceptance was not so universal as is guaranteed today. Size and weight of the airframe would be similar to the DC-3, and it would be designed from the start with emphasis heavily placed on ruggedness and simplicity and built on fail-safe principles. Although a number of changes—some fairly major, involving a re-appreciation of the tension skin principle on which the fuselage and tailplane is constructed—have been put into effect in the design of aircraft subsequent to the prototype, the guiding principles remain as before.

The prototype aircraft flew for the first time on July 9 from Southend, where two pre-production aircraft are now being built. Both machines incorporate the new design of fuselage which has a parallel centre section that can conveniently be extended to increase the seating capacity from a maximum of 28 to a maximum of 40.

AIRFRAME The problem of fatigue has been given primary consideration in the design of the airframe. Production and pre-production aircraft have fuselages of 19 s.w.g. skin over conventional frames and stringers, and the general stress level arising from pressure differential is of the order of 7,000 lb/sq in, with a maximum level at points of stress concentration of 15,000 lb/sq in. There are a total of four emergency exits provided which adequately meet both B.C.A.R. and C.A.A. requirements.

In areas such as the canopy, single load carrying members have been avoided and a design ultimate factor of 3 meets an American requirement for a factor of 1.15 on combined internal and external pressure loads with one element failed. Cabin windows abut on to a sealing ring on the skin and are clamped into position. Doors on the aircraft under construction are of the sideways opening type and will be locked by anti-jam throw-over latches. The windows are being increased in size to 14½in by 16in.

In view of the 70,000 hr airframe life achieved by some DC-3s, Aviation Traders have set their sights at an "infinite life" in designing the wing, which is in five sections. The primary bending structure is a box formed by the front spar at 19 per cent chord, a rear web at 65 per cent, and the top and bottom surfaces of conventional skin-stringer construction. The bottom skin is single heat-treated L.64 or L.72 and, apart from multi-bolted joints outboard of the engines and inboard of the ailerons, is unbroken by cut-outs from the tip to the centre line of the fuselage, where another multi-bolted joint occurs. On the top skin, double-heat treated D.T.D. 687 and L.65 is used, with 12 s.w.g. skin over the centre section. The end load carried by the skin-stringer combination is diffused into two compression booms across the fuselage and into a keel member on the fuselage centre line. Interaction between fuselage pressure differential and wing bending loads is thus minimized and cut-outs in the fuselage are reduced to simple reinforced slots. The lower section of the nose panels outboard of the powerplant hinges for access in daily servicing; flush-type press fasteners are used.

Flaps stretch from aileron to aileron; they are in five sections connected by articulated joints. The cranked centre section flap is single slotted, but the remainder are double slotted with their geometry so arranged that at the take-off position the slat has not opened. Extensive use of glass-fibre mouldings is to be made for non-structural parts.

A sturdy Dowty tricycle undercarriage is fitted. The main wheels retract into the nacelle "step" and the forward-retracting nosewheel protrudes slightly in the retracted position. Goodyear wheels, tyres, brakes and—on the mainwheels—anti-skid units are used.

[*Continued on page 716*

AIRLINERS OF THE WORLD

ACCOUNTANT . . .

POWERPLANT Rolls-Royce Dart R.Da6 Mark 512 engines giving 1,730 e.h.p. for take-off are fitted in as standard an installation as possible (the standard being based on the Viscount). Immediate increases in take-off weight are not being sought, and the installation of more powerful Darts is not required to meet take-off performance requirements. Among the more functional differences in this installation are those affecting the 10ft diameter Rotol propellers. The Dart reduction gear ratio has been altered to 0.107 and the ground fine pitch stop setting is 0 deg. The flight fine pitch stop is at 19½ deg.

SYSTEMS **Flying Controls** These are a conventional all-pushrod system, only the trim controls being cable-operated. Control runs passing through the pressure cabin envelope do so with a radial motion and are sealed by pressure boxes around the bearings. Reciprocating control rods—such as those passing through the wing roots—are sealed by long glands.

The main engine controls are grouped on a central console—enlarged on aircraft subsequent to the prototype—on which are also placed trim, undercarriage and flap selector levers. The flight instrument panel was laid out following the canvassing of pilot opinion as to the best arrangements. Access for maintenance and conversion to foreign standards is good.

Fuel The system has been kept very simple. A 565 Imp. gal capacity integral tank in each wing outboard of the nacelles feeds its own engine, but a cross feed is also provided. A fuel booster pump is installed on each spar in specially designed pump compartments which enable pumps to be changed without first draining off the fuel. Access to the tanks is through detachable manhole covers in the front spar web. The tank structure is sealed without recourse to sealing strip; Bostick preparations are used throughout. Provision has been made for the optional installation of additional 80 gal bag tanks each side; the total fuel capacity is 1,280 Imp. gal. Inboard of the integral tanks are two bag tanks each containing 32 Imp. gal of water methanol which is injected at temperatures in excess of I.S.A. to maintain take-off power. The capacity is sufficient for six minutes' operations at I.S.A.+30 deg C.

Refuelling can be either by pressure through refuelling valves, or by gravity through an overwing refuelling cap. Smiths' Waymouth gauges are employed for contents indication, and this system is used to establish the amount of fuel fed into the tanks by the refueller. The fuel capacity can also be checked by dipsticks.

Cabin Air Fresh air (with no recirculation) is supplied by blowers, heat exchangers and a cold-air unit in the centre section. The cabin is pressurized to give 8,000ft cabin conditions at 25,000ft. Twelve complete changes of air are made per hour. A ground ventilation fan and filter can be included and the standard ducting provides a connection for the use of an air conditioning ground service truck.

Electric The electric system consists of a 28-V D.C. earth return system supplied by two 6 kW D.C. generators on the prototype and 9 kW generators on production aircraft, one of which is driven from each engine. Four 24-V 25 amp-hr batteries are fitted, one of which is the normal aircraft battery and three of which are provided for emergency supply and engine starting if no external supplies are available.

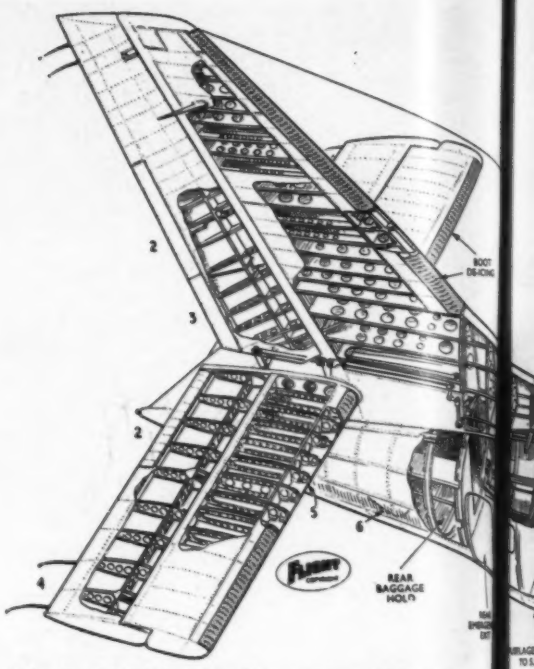
Engine and propeller de-icing power is provided by two 7.5 kVA three-phase alternators; each engine de-icing load is supplied from its own alternator. Three rotary inverters supplying 115-V A.C. for flight instruments can be fitted to suit specific requirements.

Hydraulic System Undercarriage and doors, flaps, brakes and nosewheel steering are operated on D.T.D. 585 oil supplied at 3,000 lb/sq in from two Lockheed Mk 9 pumps. An emergency hand pump (also for ground testing) is fitted. A total of four accumulators are installed: one for the normal system, two to provide normal and emergency wheel brake power and one used for emergency undercarriage lowering. The wheels are automatically braked on selection of "undercarriage up."

The flaps are operated by two Dowty jacks, one in each wing. Should one fail, sufficient power remains for partial operation, and a secondary system is provided in the charge of solenoid-operated selectors by which flaps may be lowered with the handpump.

Flight Deck Although the cockpit is fairly small, it has adequate head room and width. Both pilots' seats are mounted on runners and slide back clear of the central pedestal to give ample access to the seats. A direct vision panel in the windscreen slides back to give a wide angle of clear vision to the sides and ahead, and both wing tips can be seen from the cockpit. Mechanical windscreen wipers and anti-icing spray equipment are fitted.

The layout of all cockpit equipment and instruments has been designed to generally accepted British standards, but it can—and would—be modified to suit the requirements of particular customers. In later aircraft a British or American weather radar



scanner will be fitted behind a glass-fibre nose cap. The display tube will be mounted aft of the centre instrument panel.

Radio The radio station is on the starboard side of the aircraft behind the second pilot. Equipment is installed in standard S.B.A.C. racking in the prototype, but equipment and installation will be fitted to customers' requirements on production aircraft. The prototype is fitted with dual V.H.F. transmitter/receivers, an A.D.F. receiver, I.L.S. equipment and crew intercommunication.

PAYLOAD ACCOMMODATION The adaptability of the Accountant has resulted in a wide choice of interior arrangements being available. Typical versions are (a) an executive aircraft for ranges of up to 2,000 miles with seats for eight or nine or alternatively 18 passengers; (b) a 28-seat feeder liner with a wide rear door for loading freight in a mixed passenger/freight configuration; (c) an all-freight version with a capacity of 1,670 cu ft; (d) a Mark 2 version with 40 seats.

Discussions are now in train concerning Accountant production. If sufficient orders are obtained ("considerable overseas interest," particularly in the executive version, has been expressed), the aircraft might be built by a major aircraft group. The price of the Accountant has been given as £120,000 to £150,000, depending upon the equipment installed.

AVIATION TRADERS ACCOUNTANT

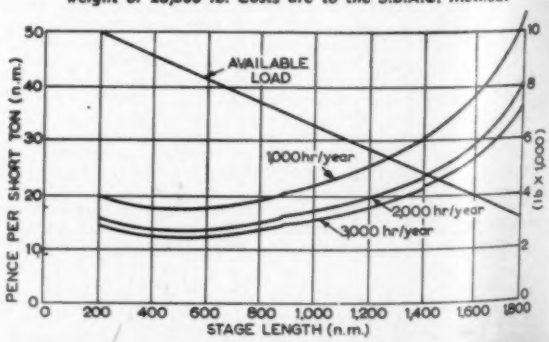
Two Rolls-Royce Dart (512) turboprops of 1,730 e.h.p.

Dimensions: Span, 82ft 6in; overall length, 62ft 1in; overall height, 25ft 3in; wing area, 632 sq ft; aspect ratio, 10.77; wing loading, 44.3 lb/sq ft; total fuselage capacity, 1,670 cu ft.

Weights: Initial gross weight, 28,500 lb; initial max. landing weight, 27,100 lb; zero fuel weight, 26,500 lb; fuel, 1,280 Imp. gal.

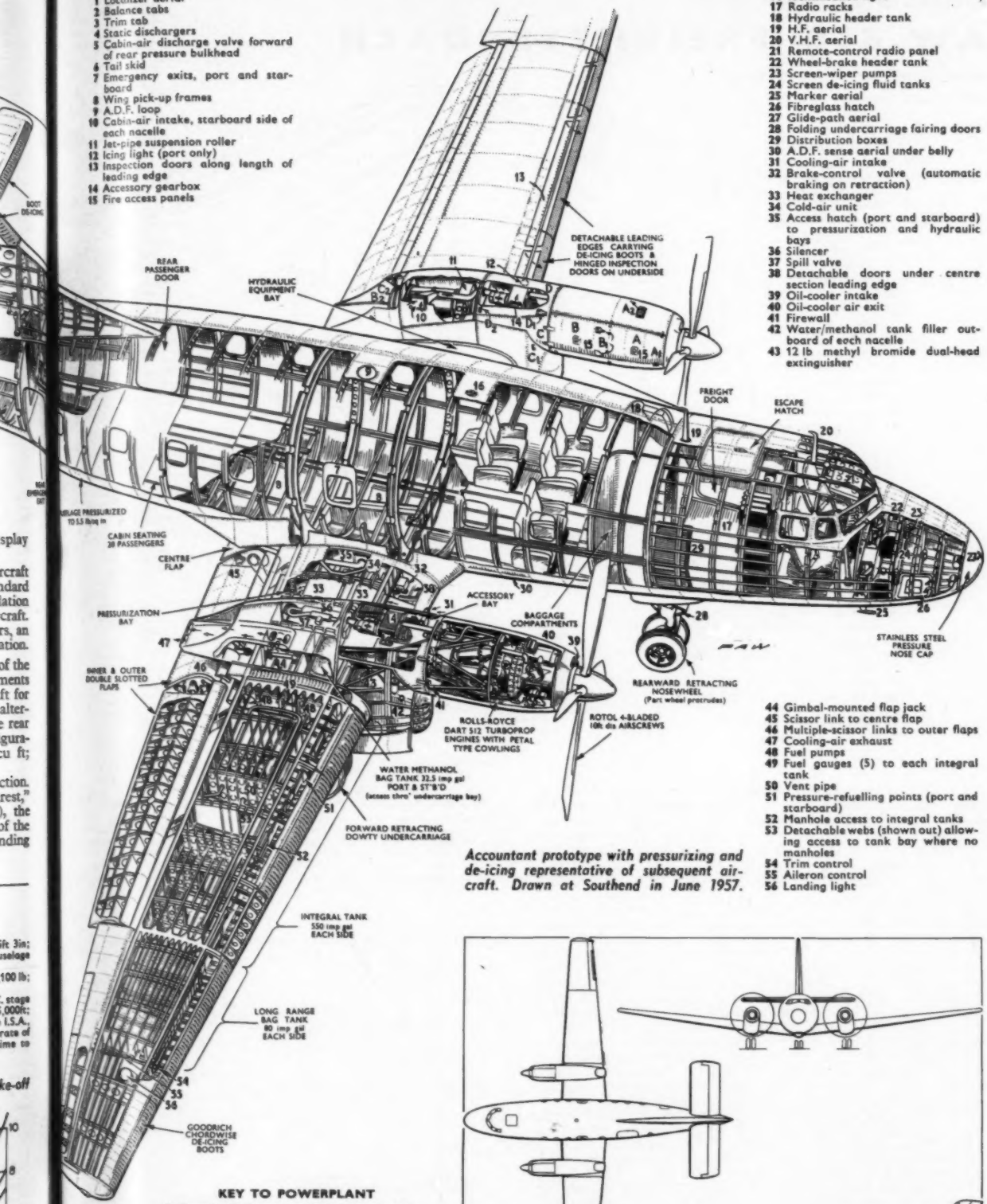
Performance: Maximum V.F.R. stage-length, 2,420 st. miles; max. V.M.C. stage with 28 passengers and luggage, 1,020 st. miles; operating altitude, 25,000ft; mean cruising speed, 295 m.p.h.; sea level balanced field length at 28,500 lb I.S.A., 3,220ft; at I.S.A.+15 deg C, 3,400ft; at I.S.A. and 5,000ft altitude, 4,000ft; rate of climb, sea level and I.S.A., 1,500ft/min; single-engine climb, 500ft/min; time to 25,000ft (two engines), 27.6 min; stalling speed, 69 kt.

Payload-range and direct operating costs for the Accountant at take-off weight of 28,500 lb. Costs are to the S.B.A.C. Method.



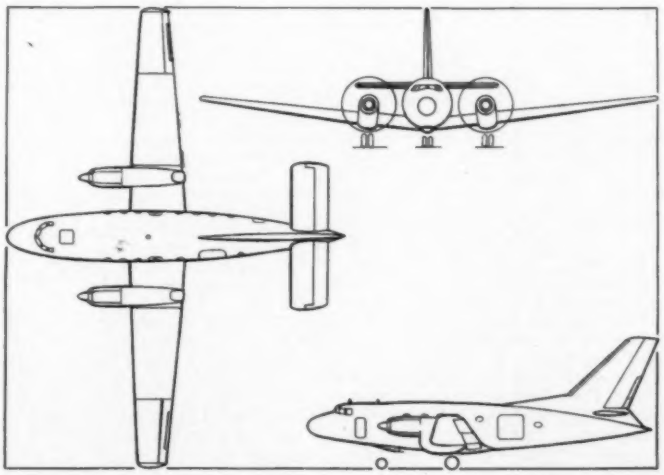
1 Localizer aerial
2 Balance tabs
3 Trim tab
4 Static dischargers
5 Cabin-air discharge valve forward of rear pressure bulkhead
6 Tail skid
7 Emergency exits, port and starboard
8 Wing pick-up frames
9 A.D.F. loop
10 Cabin-air intake, starboard side of each nacelle
11 Jet-pipe suspension roller
12 Icing light (port only)
13 Inspection doors along length of leading edge
14 Accessory gearbox
15 Fire access panels

16 Identification light
17 Radio racks
18 Hydraulic header tank
19 H.F. aerial
20 V.H.F. aerial
21 Remote-control radio panel
22 Wheel-brake header tank
23 Screen-wiper pumps
24 Screen de-icing fluid tanks
25 Marker aerial
26 Fibreglass hatch
27 Glide-path aerial
28 Folding undercarriage fairing doors
29 Distribution boxes
30 A.D.F. sense aerial under belly
31 Cooling-air intake
32 Brake-control valve (automatic braking on retraction)
33 Heat exchanger
34 Cold-air unit
35 Access hatch (port and starboard) to pressurization and hydraulic bays
36 Silencer
37 Spill valve
38 Detachable doors under centre section leading edge
39 Oil-cooler intake
40 Oil-cooler air exit
41 Firewall
42 Water/methanol tank filler outboard of each nacelle
43 12 lb methyl bromide dual-head extinguisher


DETACHABLE LEADING EDGES CARRYING DE-ICING BOOTS & HINGED INSPECTION DOORS ON UNDERSIDE
REAR PASSENGER DOOR
HYDRAULIC EQUIPMENT BAY
FREIGHT DOOR
ESCAPE HATCH
CABIN SEATING 28 PASSENGERS
CENTRE FLAP
ACCESSORY BAY
BAGGAGE COMPARTMENTS
PRESSURIZATION BAY
INNER & OUTER DOUBLE SLOTTED FLAPS
STAINLESS STEEL PRESSURE NOSE CAP
REARWARD RETRACTING NOSEWHEEL (Part wheel protrudes)
ROLLS-ROYCE DART 512 TURBOPROP ENGINES WITH PETAL TYPE COWLINGS
ROTOL 4-BLADED 10ft dia AIRSCREWS
WATER METHANOL BAG TANK 32.5 imp gal PORT & ST'B'D (access thro' undercarriage bay)
FORWARD RETRACTING DOWTY UNDERCARRIAGE
INTEGRAL TANK 550 imp gal EACH SIDE
LONG RANGE BAG TANK 80 imp gal EACH SIDE
GOODRICH CHORDWISE DE-ICING BOOTS

Accountant prototype with pressurizing and de-icing representative of subsequent aircraft. Drawn at Southend in June 1957.

44 Gimbal-mounted flap jack
45 Scissor link to centre flap
46 Multiple-scissor links to outer flaps
47 Cooling-air exhaust
48 Fuel pumps
49 Fuel gauges (5) to each integral tank
50 Vent pipe
51 Pressure-refuelling points (port and starboard)
52 Manhole access to integral tanks
53 Detachable webs (shown out) allowing access to tank bay where no manholes
54 Trim control
55 Aileron control
56 Landing light



KEY TO POWERPLANT

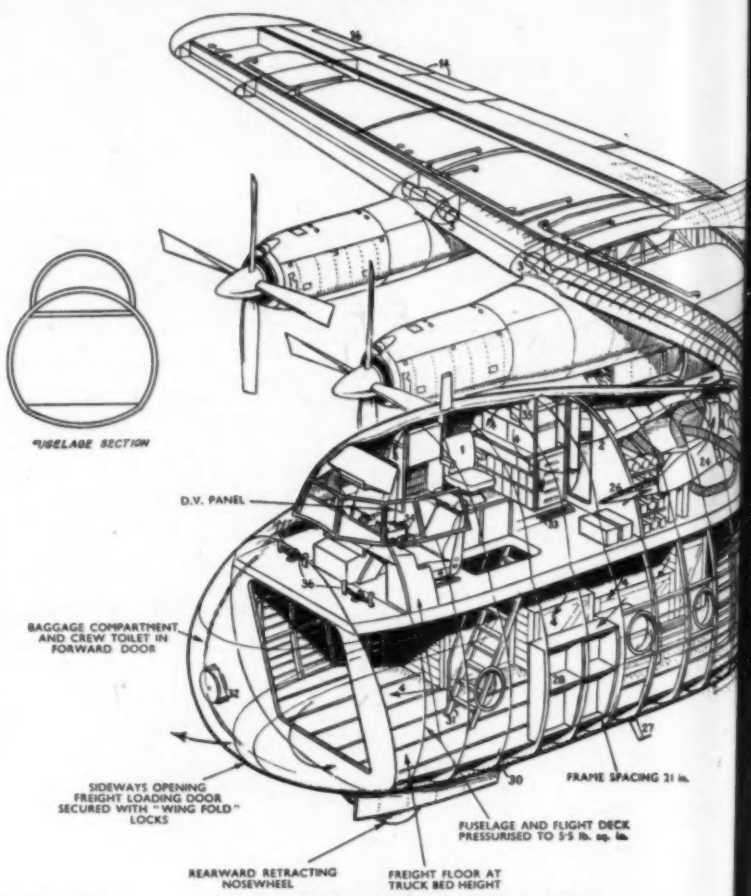
A Zone 1, **B** Zone 2, **C** Zone 3, **D** Zone 3a
A1 Ventilation air intake to zone 1
A2 Ventilation air exit to zone 1
B1 Ventilation air intake to zone 2
B2 Ventilation air exit to zone 2 into jet pipe
C1 Ventilation air intake to zone 3
C2 Ventilation air exit to zone 3 around jet pipe
D1 Ventilation air intake to zone 3a
D2 Ventilation air exit to zone 3a

AIRLINERS OF THE WORLD

AW.650 FREIGHTERCOACH

Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton, nr. Coventry

1 Seat for supernumerary
2 Crew escape hatch
3 Leading-edge thermal de-icing ducts
4 Airflow from distribution duct in fuselage
5 Service door
6 Navigation light
7 Trim tab
8 Spring tab
9 Geared tab
10 Trim-cum-geared tab
11 Spring tab
12 Passenger door
13 Fairlead channels
14 Spring tabs
15 Trim-cum-geared tab
16 Geared tab
17 De-icing air outlets
18 Fuel-tank vent pipes
19 Tubeless tyres, wheels and Maxaret brakes
20 Oil cooler
21 Nacelle support struts from front spar
22 Jet-pipe
23 H.F. aerials
24 Heat exchanger
25 Four escape hatches
26 N.A.C.A. cooling-air intakes
27 Pitot head
28 Cupboard
29 Nineteen double-skinned windows, clamped into position
30 Nosewheel door fairing
31 Retractable ladder to flight deck
32 Radar scanner
33 Flying controls passed along in sandwich floor
34 S.E.P.2 autopilot
35 Crew compartment air-distribution duct
36 Duplicated pilots' controls
37 Elevator horn balance


FUSELAGE SECTION
D.V. PANEL
BAGGAGE COMPARTMENT AND CREW TOILET IN FORWARD DOOR
SIDEWAYS OPENING FREIGHT LOADING DOOR SECURED WITH "WING FOLD" LOCKS
FRAME SPACING 21 in.
FUSELAGE AND FLIGHT DECK PRESSURISED TO 5·5 lb. sq. in.
REARWARD RETRACTING NOSEWHEEL
FREIGHT FLOOR AT TRUCK BED HEIGHT

ARMSTRONG WHITWORTH A.W.650

Four Rolls-Royce Dart 526 (RDa.7/2), each rated at 2,100 e.h.p.

Dimensions: Span, 115ft; length, 86ft 9in; height, 27ft; gross wing area, 1,450 sq ft; aspect ratio, 9.12; **Hold:** volume (gross), 3,680 cu ft, (usable), 2,630 cu ft; floor area, 426 sq ft; floor length, 46ft 8in; floor width, 10ft; clear interior height, 80in or more; floor height above ground (aircraft loaded), 4ft; min. dimensions of forward door, 100in by 80in; min. dimensions of rear door, 104in by 80in.

Weights: Max. take-off, 82,000 lb (76,000 lb for initial C. of A. application);

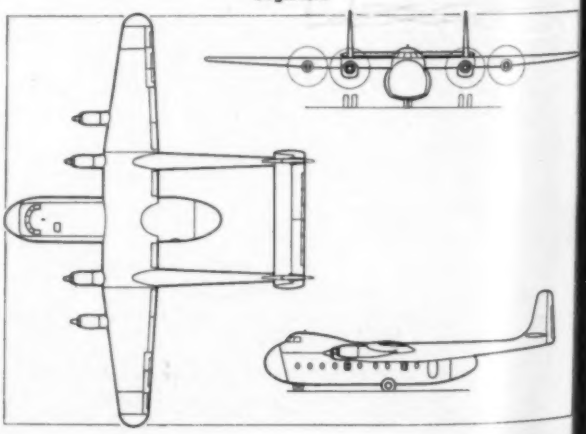
A GOOD basic aircraft design, like a good musical theme, is enhanced by the variations which can be played upon it. That so many alternative versions of the A.W.A. Freighter-coach should have been put forward at this stage of the project is an indication of the versatility of the initial design. In autumn 1955, Armstrong Whitworth were invited to submit a project study for a multi-purpose military transport with obvious civil applications.

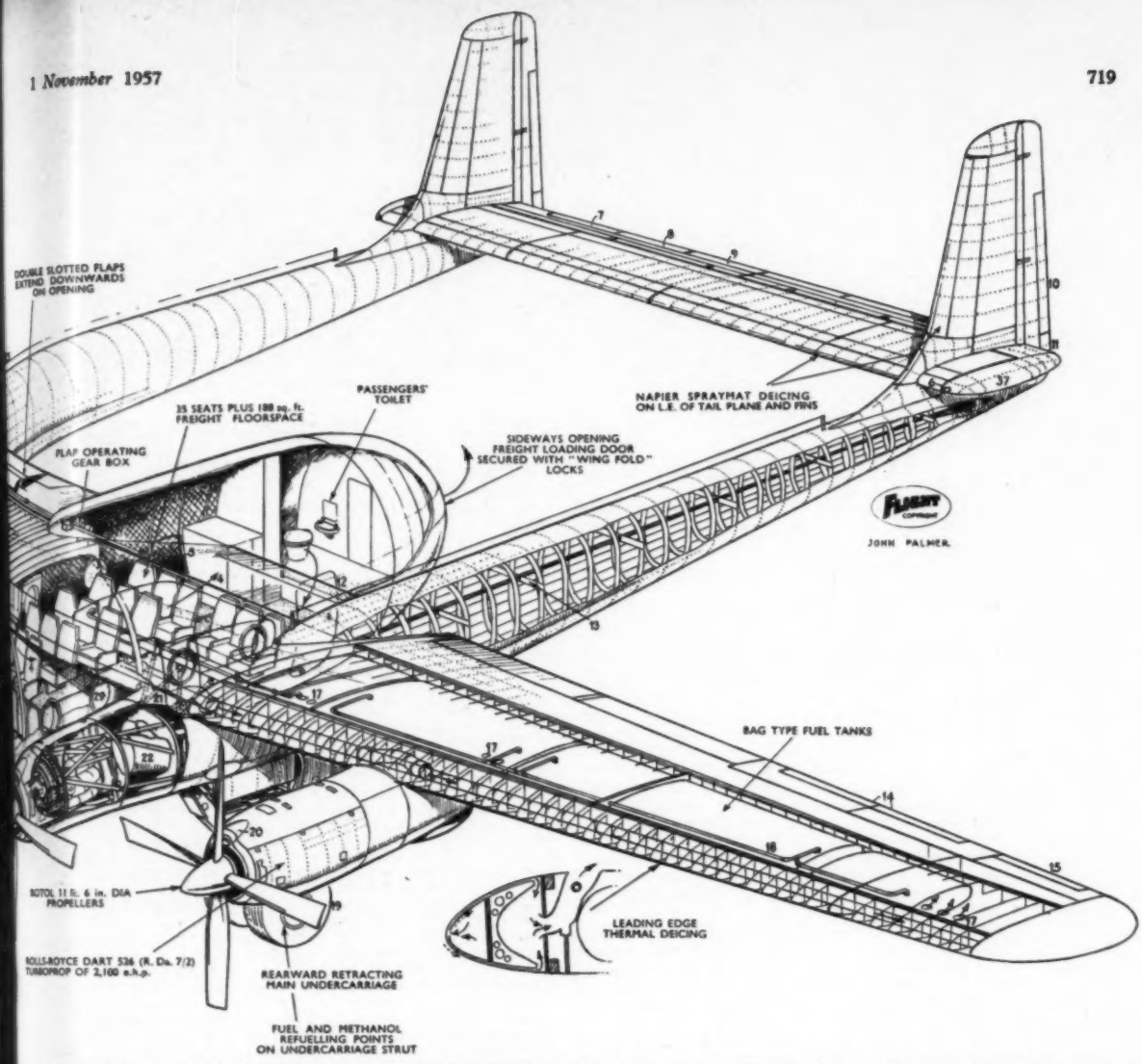
Later, under the M.T.C.A. instead of the M.o.S., the project became a predominantly civil one, backed as a private venture by the Hawker Siddeley Group. The result of an intensive market survey showed that initially four well-proven Rolls-Royce Dart powerplants should be used, but it was decided also to profit from the low installed drag and efficiency of the Tyne to offer another version with this engine for longer stage-lengths. These versions became respectively the AW.650 and 651, both with a twin-boom layout, a wing of well-proven merit and a pressurized fuselage of approximately circular section. Discussions quickly showed the possibilities of the type as a military freighter with an integral ramp for dropping stores (AW.660), a similar version with Tyne engines (AW.661) and a further variant with an enormous unpressurized double-deck fuselage, with a floor-level width of 174in, on which further changes could be rung. These are a car ferry which would accommodate six cars and 30 passengers, designated AW.670, or a short-range "air bus" with 130 seats, the AW.671. Another variant that has been considered is a fuselage based on the AW.650 configuration but reduced in length.

The project is being tackled with appropriate intensity from the outset. Two complete airframe test shells are being constructed, and work is in hand on three prototypes which are scheduled to fly from Bitteswell in October 1958, December 1958, and February 1959. These will be followed by seven pre-production AW.650s between April 1959 and March 1960. Described below is the basic long-fuselage, four-Dart-powered AW.650 now under construction.

STRUCTURE The twin-boom configuration was a logical

The Dart-powered AW.650 Freightercoach under construction at Baginton.

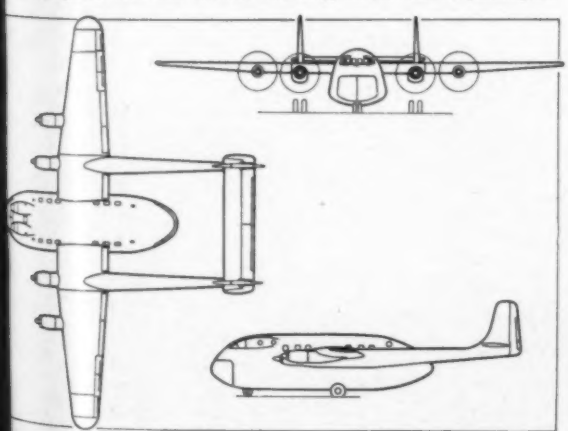



DOUBLE SLOTTED FLAPS EXTEND DOWNWARDS ON OPENING
35 SEATS PLUS 180 sq. ft. FREIGHT FLOORSPACE
PASSENGERS' TOILET
NAPIER SPRAYMAT DEICING ON L.E. OF TAIL PLANE AND FINS
FLAP OPERATING GEAR BOX
SIDEWAYS OPENING FREIGHT LOADING DOOR SECURED WITH "WING FOLD" LOCKS
FLIGHT COPYRIGHT
JOHN PALMER
BAG TYPE FUEL TANKS
ROTOL 11 ft. 6 in. DIA PROPELLERS
ROLLS-ROYCE DART 536 (R. Da. 7/2) TURBOPROP OF 2,100 e.h.p.
REARWARD RETRACTING MAIN UNDERCARRIAGE
LEADING EDGE THERMAL DEICING
FUEL AND METHANOL REFUELLING POINTS ON UNDERCARRIAGE STRUT

landing, 73,000 lb; zero fuel, 70,000 lb; structure weight, 24,400 lb; empty weight, 39,190 lb; basic operating weight, 39,850 lb.

Performance: Average cruising speed, (13,600 r.p.m.) 276 m.p.h., (14,000 r.p.m.) 286 m.p.h.; range with 25,000 lb payload (no reserves), 1,830 st. m.; max. range with 15,400 lb payload, 3,000 st. m.; take-off field length (s.l., I.S.A.), 4,050ft; take-off field length (4,000ft and I.S.A.+15 deg C), 5,550ft; min. all-engines-operating take-off, 3,050ft; approach speed, 117 m.p.h.; landing distance, 2,280ft; performance ceiling, 23,000ft; three-engine performance ceiling, 20,000ft.

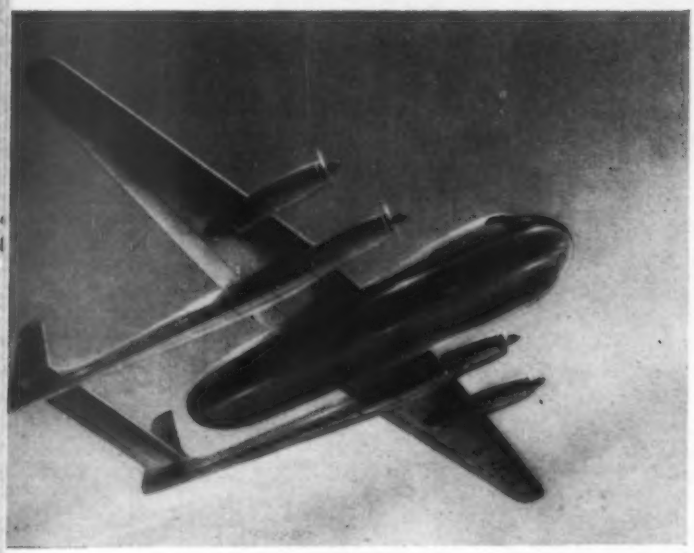
The projected four-Dart AW.670 car ferry; six cars and 30 passengers.

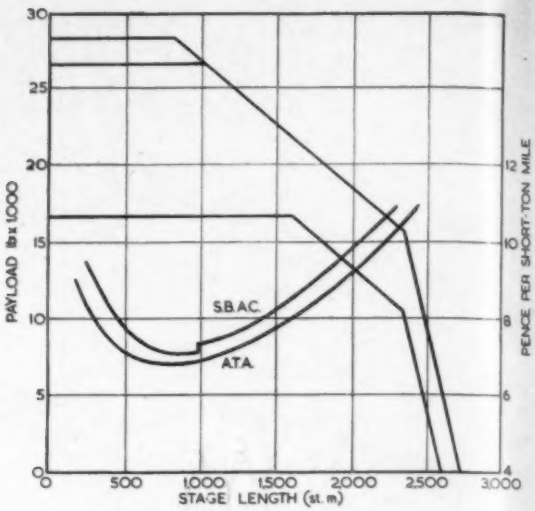


choice for the operating rôle of the aircraft, and the same tail/boom/wing/powerplant arrangement is used to form a basic carrying vehicle for at least three distinct fuselages.

Fuselage The capacity of the long fuselage is 3,680 cu ft (that of the shortened AW.650 fuselage is about 3,000 cu ft) with a floor width of 10ft, an area of 426 sq ft, and a minimum vertical clearance between the floor and wing spars of 6ft 8in. In section, the fuselage has been compared to that of the Ambassador; roof and belly curves are struck from two radii, sides from a third and there is a well-defined chine at the level of the floor and a less prominent one at roof level. The floor is four feet above the ground and both loading doors are at truck-bed height. The fuselage is of conventional stressed-skin construction with I-section frames, generally at 21in pitch, backed by doubling strips with intercostal stringers riveted through; two robust additional double-frames carry loads into the centre-section spars. The interior is pressurized to a dP of 5.5 lb/sq in and the end doors are closed on inflatable seals. The front door, which is faced with a bulkhead, incorporates a large baggage compartment and the crew toilet. In addition to the freight loading doors there is a 66in by 30in passenger door on the port side aft and an emergency exit 48in by 24in opposite. Four of the 19 windows also function as emergency exits, two 36in high by 20in wide and two more 26in high by 19in wide, the latter positioned between frames pitched at 23.5in.

Wing During the preliminary design it was found that a modification of the Shackleton 3 wing would be very suitable for the AW.650. The responsibility for the wing has hence been invested in Avro at Manchester, where as much of current Shackleton tooling as possible will be used. Fatigue experience with this type of wing is considerable, and a safe life in normal operation of 30,000 hr can be predicted with confidence. The final wing is in fact now much modified in detail largely because of the tail-boom attachments and different engine spacing. Nevertheless, the basic three-section, two-spar design is retained,





Payload-range and direct operating costs for the AW.650.

AIRLINERS OF THE WORLD

AW.650 FREIGHTERCOACH . . .

with spars (consisting of upper and lower booms with conventionally stiffened webs) at about 13 per cent and 62 per cent chord. The section is modified N.A.C.A. 23018 at the root, tapering to N.A.C.A. 23012 at the tip. The main constructional break occurs 30in outboard of the boom centre-line, the outer wing having two deg of dihedral. The leading edge is hinged for accessibility. Carried from the rear spar are hydraulically operated, double-slotted flaps extending over 31 per cent of the chord and out to the three-piece ailerons. The linkage is designed to give a large chordwise extension over the initial range of travel. The mechanism consists of a main and emergency motor, and a worm and wheel gearbox driving a bevel box through an output shaft to give continuous torque-tube operation to the respective chain and sprocket-driven flap portions. A smaller flap, 163in wide, is set into the centre section between the boom and the fuselage, so that 64 per cent of the total wing span is flapped.

Tail Unit Final design of the complete tail unit is being undertaken by Gloster Aircraft. The tail is supported on long semi-monocoque booms of flattened circular section extending from the rear of the inboard engine nacelles. The tailplane is of conventional two-spar multi torsion-box construction and carries horn-balanced elevators with six sections of tab.

Undercarriage This is the responsibility of Dowty. The main units, somewhat similar to the Friendship geometrically, are hydraulically retracted rearwards into the booms, where they are closed by two doors (one for the leg and one for the wheel) hinged outboard of the centre-line of the nacelle. Twin Dunlop wheels are fitted with Maxaret anti-skid units and Dunlop 15.5 × 20 tubeless tyres inflated to 74 lb/sq in. The nose undercarriage, which is also retracted rearwards into a box is free to caster through 360 deg and can be hydraulically steered through a range of ±55 deg. The tyre size is 32 × 10.75-16 and the inflation pressure 70 lb/sq in.

POWERPLANT Choice of the RDa.7/2 (Dart 526) engine of 2,100 e.h.p. was followed-up by A.W.A. obtaining permission from Vickers to allow them to buy Viscount-type powerplants complete back to the fireproof bulkhead. A typical cruising speed over medium stages with this engine would be 276 m.p.h. t.a.s. at 25,000ft.

Tyne versions of the Freightercoach may, under some conditions, be limited in take-off performance with the Tyne RTy.1 (4,695 e.h.p.) installed, but the two-spool turboprop would offer greater fuel economy and lower specific installed weight.

A larger propeller than that fitted to the Viscount is to be used; it will be an 11ft 6in constant-speed, feathering Rotol propeller fitted to a Friendship-type hub.

SYSTEMS **Cabin Air** Pressurization air at 5.5 lb/sq in is supplied by three Godfrey Type 15 blowers driven through the Rotol gearboxes on engines one, two and four. Air is drawn through filters and then passes through silencers into a pressure-limiting valve, primary and secondary heat exchangers (cooling air for which is ducted from N.A.C.A. scoops aft of the cockpit windows) a secondary silencer and a temperature-control valve. The air-conditioning equipment is installed in a compartment aft of the flight deck and above the freight hold, and provides up to 100 lb/min of conditioned air through distribution ducts throughout the length of the main cabin, around the crew compartment and into de-misting jets on the side and d-v. windscreen panels.

Fuel The fuel is contained in ten bag tanks between the wing spars, with a total capacity of 3,300 Imp. gal. The capacities of individual tanks, from root to tip, are 362 Imp. gal, 463 gal, 405 gal, 320 gal and 100 gal. A pressure refuelling and defuelling system is installed, with filling points on each main undercarriage leg. Normal over-wing refuelling is available as well. The pressure refuelling rate is 150 gal/min through each point.

Flying Controls The manual flying controls are quite conventional. Spring tabs operated through push-pull rods, and tension-compensated control cables are installed. Elevator movement is 25 deg up and 15 deg down, rudder movement ±20 deg, and aileron movement 24 deg up and 14 deg down. Trimming is by tabs on each surface.

De-icing The wing leading edge is thermally de-iced by ram air heated by exhaust gas tapped from the inboard engines and passed through heat exchangers. The heated air is passed through the hinged, double-skinned leading edge assembly via a double-skinned nose and exhausted through outlets at three stations along the span just aft of the front spar, between ribs 3 and 4, 11 and 12 and 21 and 24. The area protected by warm air extends back to 12 per cent chord. Propellers, engine intakes and tail surfaces are electrically de-iced by both continuous and cyclically heated systems.

Hydraulics Power is supplied by Lockheed Mk 9 pumps mounted on the accessory gearboxes of engines 1, 2 and 3. The system operates on D.T.D.585 (mineral) at 2,500 to 3,000 lb/sq in (except for the duplicated wheel-brakes supply, which operates at 1,500 lb/sq in) and serves undercarriage retraction, nosewheel steering and flaps. An Integral emergency power pack supplies the undercarriage and flaps, and a double-acting hand pump is fitted. The Hobson reservoir is pressurized by the cabin blower to 10-12 lb/sq in.

Electrics The main generator system comprises four 6-kW 28-V engine-driven D.C. generators, running in parallel and supplying a split busbar. Three 25-amp-hr 24-V accumulators are fitted to give engine starting without using ground facilities. The A.C. power requirements for radio and radar are supplied by inverters, and four 22-kVA alternators supply the heavy power needed by the electric de-icing units.

FLIGHT DECK Normally, the aircraft will be flown by a crew of two, although provision is made for three, and the aircraft can be ferried solo. Pilot opinion has been freely and extensively employed in the design of the cockpit, and the resulting layout should prove exceptionally popular and efficient. Specified equipment includes the Smiths Flight System and S.E.P.2 autopilot, duplicated controls, and seats mounted on rails on each side of a large central console with plenty of room for access. Roof panel provision is for radio, cabin-conditioning, de-icing and generator and invertor control systems. Standard equipment is an I.L.S./V.O.R., two A.D.F.s based on Marconi A.D.712, an STR.18-based H.F., twin STR.12D V.H.F., and Ultra intercommunication equipment. Decca Navigator and weather radar (based on the Ekco E.120) will be available to special order. H.F. aerials are strung along each boom, A.D.F. sense towel-rail aerials are situated beneath the rear fuselage with tandem loop aerials under the centre fuselage, and two V.H.F. aerials project from above the cockpit and low on the starboard side of the fuselage. The I.L.S. marker aerial is in the fuselage behind the nosewheel fairing, the glide-path aerial is in the nose, and the localizer and V.O.R. aerials are situated half-way up the fin.

PAYLOAD ACCOMMODATION Conversion between all-freight, mixed passenger/cargo and all-passenger services has been carefully considered. The aircoach version of the standard Freighter provides for 77 passenger seats at 34in pitch, with toilet and galley facilities for medium stages, or 74 seats at 36in pitch, 77 at 34in and 83 at 32in. The ferry version (AW.670) carries six cars and 30 passengers, and the AW.671 can carry up to 130 passengers over short stages.

COMMERCIAL HISTORY With the sales of all variants in the hands of the Hawker Siddeley Group, and aided by the very widespread Rolls-Royce sales organization, commercial success seem as assured as it can be for a new project. Models of the AW.650 have appeared in the markings of B.E.A., and the AW.670 car ferry in Silver City livery.

Tupolev Tu-104 (top) and Tu-110. At foot of page, Ilyushin Il-18 Moskva.

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Antonov An-10 Ukraina This very capacious high-wing monoplane is designed to operate when necessary from grass fields, and to that end the undercarriage—the main units of which retract into large fairings on the flanks of the fuselage—has low-pressure tyres. Mounted on the high-aspect-ratio wing are four Kuznetzov turboprops, each of 4,000 e.s.h.p. The propellers are steel, reversible, four-bladers, with automatic feathering. Slotted flaps are fitted and all fuel is carried in the wing. De-icing is provided not only for the wing and tail but for the engine-air intakes, oil temperature regulators, propellers and windscreen. The cabin and flight deck are pressurized by air bled from the engine compressors.

For the greater part passenger seating is six-abreast. There are three compartments, the first holding 25 passengers. Between this and the main 46-seat cabin is a buffet galley, with the necessary equipment to serve each passenger one meal, and a baggage compartment. The third passenger compartment has 13 seats, which can be readily removed should it be necessary to carry cargo. Each seat has radio headphones and individual lights. In the central compartment are divans for children. The main cargo space is in two pressurized holds beneath the passenger cabin.

The Ukraina's cruising speed varies between 370 and 400 m.p.h. Normal gross weight is 112,400 lb, and the range, with a payload of about 28,600 lb is 1,240 miles. Height can be maintained at 19,700ft on two engines.

Ilyushin Il-18 Moskva The Il-18 has been flying for some months in prototype form and is intended for service with Aeroflot and for export. Four Kuznetzov turboprops of 4,000 e.s.h.p. each (as fitted on the Ukraina), are mounted relatively high on the wing, and the main-undercarriage bogies retract into the large inboard nacelles. Gross weight is nearly 128,000 lb and seating can be provided for 75-100 passengers. A maximum payload of over 30,800 lb, combined with a cruising speed of the order of 400 m.p.h. is said to render a ton-mile operating cost lower than that of any other current transport. The wing measures 122ft 8in in span and its characteristics contribute to the short take-off and landing runs claimed (approximately 2,000ft and 2,500ft respectively). De-icing protection is provided for the wing, tail, propellers, propeller hubs and air intakes. The crew numbers five. Aft of the cockpit is a baggage compartment, wardrobe and toilet; then follows a compartment for ten passengers, the buffet galley, the main compartment for 65 passengers, a section embodying the main entrance, two additional toilets, and finally a baggage compartment.

Titanium is used in the engine nacelles.

Tupolev Tu-104 This original of the Tu-104 twin-jet series was built at the Moscow Engineering Works and was described in detail in our issue of July 6, 1956. The 50/54 passengers are seated in "palm court" comfort. Conflicting reports concerning the thrust of the twin turbojets have been rife since the Tu-104 made its first public appearance early in 1956. In an exclusive series of articles on Aeroflot, appearing in *Flight* last August, the thrust was given as 19,300 lb—a figure officially quoted to the leader of a British delegation. On the same occasion the "realistic cruising speed" was given as 515 m.p.h. and the all-up weight as more than 137,800 lb.

Tupolev Tu-104A The current production version of the series, the "A" variant carries 70 passengers in new lightweight seats, and in less exotic surroundings than does its precursor. Indicative of performance is the recent world speed record over a 1,000 km course, carrying a 10-ton payload. The average was 604 m.p.h. and a maximum of about 640 m.p.h. was reached on several occasions.

Tupolev Tu-110 The principal differences between this aircraft and the Tu-104 series is the fitting of four turbojets (believed to be of lower thrust and ascribed to A. M. Lulko); an increase in wing span of some 8ft; and a fuselage about 4ft longer. Improved economy, extended range and a higher safety factor are achieved. Up to a

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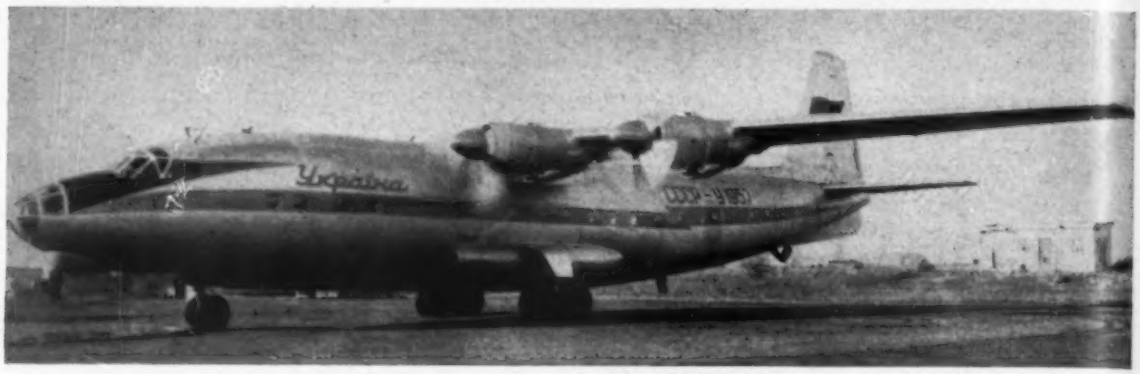
hundred passengers can be carried in addition to over 4,000 lb of baggage and some 6,000 lb of cargo. Weight has been saved by attaching the engines to the wing instead of to the fuselage frames, and—having regard to the higher wing loading—flap area has been increased. In a typical layout there are three cabins; the first for 30 persons in six rows; the second for 15 in three rows; and the third for 55 in eleven rows. Between the first cabin and the cockpit is a galley, and aft of the third cabin are two wardrobes, two toilets and a vestibule. Range with a payload of 26,450 lb is of the order of 2,000 miles (including a 1-hr fuel reserve); speed approximates to the Tu-104A's.

Tupolev Rossiya This 170/180-passenger transport should now be almost ready to fly. It is thought to have a cruising potential of 500/600 m.p.h. and a range of 4,300/5,100 miles. The type is destined for service with Aeroflot and has been reported as a civil development of the four-turboprop Bear swept-wing bomber, though this is unconfirmed. The designation Tu-114 has been mentioned.

Antonov An-10 Ukraina.



PROJECTS

BRIEFLY described on this and the next page are a number of new or projected transport aircraft. Excluded from the list are types which are featured in our special issues dealing with rotary-wing aircraft and the smaller executive machines.

Agusta-Zappata AZ-8L Powered by four Alvis Leonides 550 h.p. radial engines, the AZ-8L, Italy's only airliner project, is now virtually complete. A low-wing machine of neat and clean appearance, it has a design weight of 23,810 lb and can seat up to 26 passengers. Cruising speed can be as high as 252 m.p.h.

Avro 735 This number is believed to have been that covering a projected transport variant of the cancelled 730 supersonic bomber. Avro have stated their intention to continue with the design of a supersonic airliner.

Avro 740 On July 5 we reported upon this jet transport to the B.E.A. specification. Sir Rob Dobson, Avro managing director, then said, "We are risking many millions of our own money in this venture. . . ." Like its competitors it is designed to cruise at 600 m.p.h. over stages up to 1,500 miles. Three-engined and four-engined schemes have been studied.

Avro STOL It has been reported that Avro have a design study for a 25-seat short-field transport.

Blackburn B.107 Under this designation Blackburn have prepared a study for a Beverley development, with a pressurized fuselage of revised form, a retractable undercarriage and four 5,315 h.p. Rolls-Royce Tyne engines. Payload should be well over 30 tons.

Boeing 727 No single scheme designated 727 exists; studies have been made but no early decision is expected. The model number covers a short/medium-range jet transport powered by either two JT3s, four Avons, four JT8s, three CJ-805s or three Zephyrs. Gross weight at present lies between 80,000 and 105,000 lb (one report avers up to 135,000 lb) and the design stage-length is from 100 to 1,000 miles.

Bréguet 941 Named Intégral, this STOL is a novel fixed-wing machine intended to lift a payload of at least 6,000 lb out of a 350ft strip. Four turboprops (G.E. T58s are envisaged) are spread right across the 58ft wing and their big propellers blow back across the wing and double-slotted flaps. The first experimental machine is about to begin its flight trials. Further details were given in our May 31 issue.

Bristol 200 In existence as a major project for over a year, the Bristol 200 is a 600 m.p.h. jet to the B.E.A. specification. It has been studied in various configurations, one type having three Bristol Zephyrs (Olympus 551 series) at the tail-end and another having four Rolls-Royce R.B.140s alongside the rear fuselage.

Britannia Development In our July 6, 1956, issue we gave a complete appraisal of Bristol's design thinking at that date on later Britannias powered by Orion engines. Project work is still in hand on the Britannia 400 and on the larger Bristol 187.

Canadair CL-44 Described in our August 23 issue, the CL-44 is a development of the Bristol Britannia, powered by four Bristol Orion turboprops. Weighing between 185,000 and 200,000 lb, and cruising at over 400 m.p.h. for ranges up to 5,000 miles, the CL-44 is being marketed by Canadair as a civil and military freight and passenger machine for service from late 1959. Eight are on order for the R.C.A.F.

CASA-207 Azor Powered by two 2,040 h.p. Bristol Hercules engines, this Convair-like aircraft has been flying in prototype form for many months and is relatively well-developed. Normal operating weight is approximately 23,300 lb and gross weight 37,480 lb, provision being made for from 30 to 40 passengers in an unpressurized cabin. Normal cruising speed is 217 to 258 m.p.h. and the Azor has been designed to operate over stages from 200 to 950 miles.

Dassault Project As far as is known this French company are not actually engaged in the design of a supersonic transport, although they have announced their interest in this field. On the other hand plans are well advanced for the development of a "Heron replacement" with outstanding short-field performance. It may have four 750 h.p. Turboméca Bastan turboprops.

D.H.121 This company model number refers to one of the jet transports under consideration by B.E.A. Powerplants are reported to be either three Rolls-Royce R.B.141s (scaled-down Conways) or four R.B.140s.

D.H.C.4 Caribou Designed as a multi-purpose utility transport for arduous civil and military short-field operations, the

Douglas Model 1940.

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Caribou is an STOL machine powered by two Pratt and Whitney R-2000 radial engines each of some 1,450 h.p. Gross weight is to be 24,000 lb, design payload 7,320 lb or 27 passengers, usable volume 1,052 cu ft (entered by a large rear ramp-door) and cruising speed 185 m.p.h. Intense development will be necessary to meet the first-flight date next summer; the design has now been finalized with a single fin. The first batch (aircraft Nos. 3 to 7) will be delivered from February 1959 to the U.S. Army for an aggregate price of some $2.5m.

Douglas In our July 6, 1956, issue we published the specification (as it then was) for the Model 1925, or DC-9. This project is still awaiting a market. Douglas feel that the scaled-down DC-8 formula is logical.

They also believe strongly in the future of the four-turboprop, straight-wing machine for economical load-carrying. As a first step they are still interested in the practicability of making an improved DC-6B with four Rolls-Royce Dart 540-series engines (which would also be a possible retroactive modification).

The bigger DC-7D is also an active project, based on the Seven Seas. Powered by Rolls-Royce Tynes (Stage I or II) it would have a larger, swept vertical tail, a more rakish windshield to reduce noise, a nearly circular hull 10in wider, and outboard engines moved 30in closer to the tips to allow for 16ft 6in propellers. Costing just under $3m, the passenger 7D could carry from 80 to 135 (five-abreast) and the freighter could lift a 70,000 lb payload for 1,600 miles with reserves. Cruising speed would vary from 405 to 445 m.p.h. according to engine type. Field-length should not exceed 5,000ft. The 7D could be certificated and delivered before the end of 1960. American Airlines were close to ordering 7Ds last summer.

Another major field being explored by Douglas is that of the perennial "DC-3 replacement." The Model 1940 study (developed in parallel with the carrier-based Model 1906 and 1906A) was described in our issue of April 5 last. This is still only a study: current feeling is that four Darts or T55s are the optimum powerplant, that seating should not exceed 70, that field length should not exceed 2,500ft and that wing loading should not exceed 60 lb/sq ft (without any "devices" such as flap-blowing).

Dresden BB-152 In our issue of November 30, 1956, we published a three-view drawing and specification for the BB-152 jet transport which has been designed by a Dresden Aircraft Institute team led by Prof. Bruno Baade. Powered by four 6,000 lb turbojets (of a new type developed in Eastern Germany with Soviet assistance) mounted in two twin under-wing pods, the BB-152 is said to have a gross weight of 110,000 lb, a span of 93ft, a length of 103ft and a seating capacity of from 50 to 80. The aircraft is intended for inter-city service, having a maximum range of some 2,000 miles at 530 m.p.h. A novel feature is the tandem bicycle undercarriage, with outriggers at the wing tips. At the critical unstick speed the rear main gear folds partially upwards, or "squats," to increase angle of attack; combined with very large slotted flaps this reduces take-off run to 3,130ft. It is hoped to place the BB-152 in production by 1960.

Fairchild Turboboxcar The basic advantages of the design of the C-123 Provider—a Chase design which Fairchild have built in quantity for the U.S.A.F.—are such that the company have developed from it a very attractive STOL multi-purpose freight and passenger machine powered by four 1,600 h.p. turboprops. Weighing 75,000 lb, the Turboboxcar would employ flap-blowing to reduce take-off and landing distances to some 1,700ft. A payload of 21,439 lb could be hauled an ultimate distance of 1,500 miles at 216 kt (248 m.p.h.). Engines will probably be Lycoming T55s or Rolls-Royce Darts.

Frye Safari Originally proposed as a simple STOL multi-purpose machine powered by four 600/800 h.p. piston engines (see *Flight* for July 6, 1956), the Safari is now being developed in F.2 form. The new project is to have two Dart RDa.7/2 turboprops inboard and two small jets (possibly G.E.J85s) outboard. The high-wing airframe has been "stretched" to accommodate up to 79 passengers, and payload-plus-fuel is given as from 19,946 lb to 24,000 lb; gross weight will be 45,000 lb. Using 17,000 lb of fuel, while cruising at 236 m.p.h. with the jets inoperative, it is theoretically possible to fly 1,615 n.m. The original F.1 design, for which several tentative orders were placed, is still awaiting a manufacturer; Frye is reported to have failed to enlist the assistance of either Grumman or North American, possibly owing to their inability to put up $15m capital.

HFB-209 A variant of the Spanish CASA-209, which is itself a projected development of the Azor (*q.v.*), the HFB-209 is a twin-Eland project under development by the Hamburger Flugzeugbau of West Germany. Of Convair configuration, the 209 is designed for a gross weight of 45,080 lb and a payload of 9,520 lb (48 to 54 seats) for a stage-length with reserves of 1,025 n.m., cruising at 319 m.p.h. Alternative powerplants are the Tyne and Allison 501.

Handley Page For many years a research team under Dr. G. V. Lachmann has been investigating the possibility of greatly reducing drag by employing boundary-layer control. A system of suction slots has been evolved during extensive flight testing and two ambitious jet transports have been proposed. Described on July 5, these projects each specify four Rolls-Royce Conway 500-series engines. One has a 154ft wing and could carry a 30,000 lb payload over a stage-distance, with full reserves, of 4,600 n.m., cruising at 515 kt (5,300 miles at 593 m.p.h.). The other, with a 198ft wing, and weighing 300,000 lb, could take the same load a stage-distance of 9,000 n.m. at 486 kt (10,363 miles at 559 m.p.h.).

Handley Page are also advocating a civil version of the Victor B.2 bomber, powered by four 500-series Conways. Data include: usable fuselage, 9,850 cu ft (extremely great); payload, 40,000 lb; take-off i.s.a. field-length, 6,120ft; cruising speed at 40,000ft, over 600 m.p.h. This aircraft could seat up to 172 passengers and would be a non-stop, year-around Atlantic machine.

Hunting Percival This company, who have prepared numerous transport studies of novel configuration, are considering the practicability of a turbojet transport in the feederline class.

Lockheed 1049 development Unofficial reports state that Lockheed's California Division are investigating the market for a development of the Model 1049H multi-purpose freighter re-engined with Electra powerplants (Allison 501 D-13s or D-15s). The structure would be stressed for a maximum payload of about 55,000 lb and purchase price about £900,000.

Lockheed 1049 development Unofficial reports state that Lock-Georgia Division are offering a commercial variant of the military C-130B Hercules for delivery in 1960. Powered by four 4,050 e.h.p. Allison 501 D-22 turboprops, the Lockheed 282A would be able to lift a maximum payload of no less than 45,000 lb. The ultimate range with this load (it is not stated what reserves are allowed) is to be 1,750 miles, and a payload of over 32,000 lb will be transportable over a distance in excess of 3,300 miles. The normal cruising speed will be 350 m.p.h. Operating cost is assessed at 3.5 pence per ton-mile (presumably long tons) and purchase price "just over £700,000."

MD-12 Now in the final development stage by the Polish national aircraft industry (see our issue for November 23 last), the MD-12 is a light twin-engined transport evolved jointly by Misztal and Duleba from the earlier C.S.S.12 (which resembled the Dove). The MD-12 is likely to weigh about 15,000 lb, to seat about 15 passengers in an unpressurized cabin, and to have good field performance. The powerplants are of the new 320 h.p. WN-3 radial type (*Flight*, July 26 last). An unusual feature of the MD-12 is its "T"-type tail unit. An order is reported to have been placed by LOT, the national airline.

Miles H.D.M. series From the H.D.M. 105, flown at the 1957 S.B.A.C. show, are being evolved the H.D.M. 106 (larger, with a 563 cu ft cabin and 340 h.p. supercharged Lycomings) and the still bigger H.D.M. 108. The latter, powered by two Turboméca Bastan turboprops of some 750 h.p. each, would weigh some 10,000 lb and carry up to 25 passengers. Main feature of these new Miles private ventures is the wing of high aspect-ratio developed in close co-operation with the Hurel-Dubois concern.

Scottish Aviation Studies exist for an STOL transport powered by two Rolls-Royce Darts, and known as the Turbo Pioneer. An artist's impression was published in our August 3, 1956, issue.

Sud-Aviation Project The director-general of Sud-Aviation stated last month that his company is engaged in the design of "a faster-than-sound Super Caravelle to put France back into the transatlantic passenger service."

Vickers-Armstrongs Viscount V.796 By matching a 700-size fuselage with a (stronger) 800-series wing, Vickers have evolved a "paper Viscount" suitable for local-service operation on stages down to 150 miles. Suitable rearrangement of galleys, coat-space and toilets can provide for up to more than 60 seats (probably with extra windows). The engines would be Dart 506s, and the aircraft would be able to fly a long route with many intermediate stops without refuelling. Gross and zero-fuel weights at present are 61,500 and 58,500 lb. Should the demand justify it, the 796 could be produced relatively quickly.

Vickers-Armstrongs VC-10 This large and fast transport is the only big jet transport outside the U.S.A. and Soviet Union to reach the detail-design stage. Powered by four 16,500 lb-thrust Rolls-Royce Conway 500-series engines it will have a big double-bubble fuselage, resembling that of the Vanguard. The VC-10 will be able to carry very heavy loads (maximum passenger accommodation will be at least 147), and "unusual features"—flap-blowing is a logical assumption—will confer an outstanding field performance. Although Vickers are financing the development, B.O.A.C. have stated their intention to buy no fewer than 35 VC-10s; originally these were for Commonwealth routes, but Vickers are now also investigating the aircraft's potentiality on the Atlantic. First delivery is scheduled for 1963.

Representing the extremes of present piston-engined transport duties: the DC-7C and the Twin Pioneer.

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PRODUCTION PISTON-ENGINED TRANSPORTS

Avia 14 This is the Czech industry's version of the Soviet Il-14, and it is now being offered for export. It was exhibited at the Paris Salon this year, where it demonstrated the very short field-performance claimed for it. Seating capacity is 32 maximum; powerplant is two M82Ts of 1,900 h.p. each; max. take-off weight 38,000 lb; payload (28-seat version) 5,605 lb; typical cruising speed 200 m.p.h.; take-off run 1,470ft; landing run 1,800ft.

Bréguet 763 Deux Ponts A fleet of 12 Deux Ponts is in service with Air France under the type-name Provence, and 15 more are in production for military or civil users. (The military version is designated 765.) Interest is at present being shown by civil operators in North and South Americas. The design philosophy of this French transport is large capacity (more than 100 passengers on two decks) for high density short-haul operations. Powerplant is four P. & W. R-2800s of 2,400 h.p.; gross weight 113,800 lb; tankage 3,960 U.S. gal; typical cruising speed 220 m.p.h. Approximate basic price: £500,000.

Convair 440 Metropolitan The Convair series of 240 and 340 twin-engined airliners have earned a fine reputation in their ten years of service on the world's regional route-networks. Latest version, which entered service early in 1956, incorporating many engineering refinements, is the 440 Metropolitan (described in *Flight*, July 6, 1956). Powerplants are two Pratt and Whitney R-2800 CB-17s of 2,500 h.p.; maximum seating is 52; tankage 1,440 Imp. gal; gross weight 49,100 lb; typical cruising speed, 285 m.p.h. To date, 146 440s have been ordered, of which 115 are for 18 airlines. Approximate basic price: $1m.

de Havilland Canada Beaver and Otter Although neither the Beaver nor the Otter was expressly designed as an airliner, these highly successful single-engined general-purpose machines must be included in this review since both have been bought for scheduled airline service. Best known operators of the Beaver are Central African Airways, who maintain a service to outlying communities in the Federation; and Philippine Air Lines are the best-known Otter airline. They have a fleet of three which maintain inter-island services. Approximate prices: $42,500 and $86,500.

de Havilland Heron 2 A small, 14-17 passenger transport powered by four 250 h.p. Gipsy Queen 30 Mk 2 engines, the Heron is in service with more than 20 airlines as a domestic "aerobus." About 96 are used for this kind of work, and in service also are another 29, mostly executive versions. Deliveries can be made in 1958. Approximate basic price: £55,000.

Douglas DC-6/7 series The members of the DC-6/7 family still issuing at the rate of about 16 per month from the Santa Monica production lines are DC-6A, DC-6B, DC-7, DC-7B and DC-7C. Total number of the series built to date, including 174 DC-6s (no longer in production) and approximately 160 military DC-6-series, is about 1,040.

DC-6A This is a cargo version of the basic DC-6 (of which 174 were sold) with special cargo doors and floors, and fuselage extended by 5ft. It is convertible to passenger-carrying. Powerplant is the Pratt and Whitney R-2800 CB-series of 2,500 h.p. Take-off weight is 107,000 lb; maximum passenger seating capacity is about 90, and capacity payload (overwater) is about 28,000 lb. Fuel capacity is 4,590 U.S. gal. By mid-October, 1957, 39 commercial DC-6As had been delivered, and the backlog of commercial orders was 34. Approximate basic price: $1.3m.

DC-6B This version is aerodynamically and (apart from loading amenities) structurally the same as the DC-6A, but designed specially for passenger work. The DC-6B is perhaps the most famous, and certainly the most economical, of the DC-6/7 series. So far 249 commercial DC-6Bs have been delivered, and the backlog of commercial orders stood (mid-October) at 40. Maximum passenger seating capacity is about 90, and capacity payload (overwater) is about 19,000 lb. Approximate basic price: $1.3m.

DC-7 This was the first of the heavier, more powerful members of the family, fitted with Wright Turbo-Compound DA engines of 3,250 h.p. Compared with the 6A and 6B, the fuselage is stretched 3ft 4in and take-off weight increased to 122,000 lb. Passenger seating capacity is about 95, and capacity payload (domestic) is about 20,000 lb. To date 108 commercial DC-7s have been delivered, and the commercial backlog is 36. Approximate basic price: $1.5m.

DC-7B Deliveries of this model, also Turbo-Compound-powered, began in 1954. Compared with the DC-7, take-off weight is increased to 126,000 lb and fuel capacity to 5,394 U.S. gal. Maximum passenger seating capacity is about 95, and capacity payload is about 22,000 lb. At mid-October, 40 commercial DC-7Bs had been delivered, and the order-book stood at 32. Approximate basic price: $1.6m.

DC-7C Seven Seas This is the latest production model of the series, of which a total of 130 have been ordered by 14 airlines and about 87 delivered. The Seven Seas is essentially a very long-range passenger transport; compared with the DC-7B the take-off weight is increased to 143,000 lb and fuel capacity (the essence of the 7C is long range) to 6,515 U.S. gal by the addition of 5ft on each side of the centre-section (increasing the span by 10ft). Passenger seating capacity is about 95, and capacity payload is about 21,000 lb. Powerplants are four Wright Turbo-Compound EA-series of 3,400 h.p. A full description appeared in *Flight*, July 6, 1956. Approximate basic price, with spares, $2.5m.

Hunting Percival President The President is the commercial development of its makers' successful series of Pembroke military transports, now adopted by seven air forces. It is offered as a transport and a feederliner. The President was described in *Flight* of October 19, 1956. The President's first order, for three aircraft, came from the new Spanish private airline T.A.E. earlier this year. Powerplant is two Alvis Leonides 503 of 540/550 h.p.; gross weight, 13,500 lb; max. payload, 3,960 lb; max. seating capacity 12; tankage, 238 Imp. gal; typical cruising speed, 150 m.p.h.; typical field length, 3,795 ft; approximate basic price: £59,000.

Hurel-Dubois H.D.321 The French firm of Hurel-Dubois is famous for its exploitation of high aspect-ratio wings, and the H.D.321 is the original transport aeroplane—roughly in the DC-3 class—which is the commercial outcome. Powerplant is two Wright 982 of 1,525 h.p.; gross weight, zero fuel and landing weight, all 41,225 lb; max. payload, 15,200 lb.

Lockheed Super Constellation Series The following types of Super Constellation are in production at Burbank: L.1049G and H, and L.1649A.

L.1049G The famous Super-G appeared in 1954. It was an exploitation of the improvements that Wright had made to the Turbo-Compound engine; fitted with improved DA-3s, of 3,250 h.p., gross weight went up from the 113,000 lb of the D. C and E models to 137,500 lb. Essentially a passenger airliner seating up to about 80 passengers, the Super-G has a maximum payload of 21,700 lb. The aircraft is distinguishable from earlier Super Connies in having wing-tip fuel tanks (500 U.S. gal. capacity each) which can be fitted for long-range operations. Total tankage is 7,500 U.S. gal. To mid-October 102 Super-Gs had been ordered by airlines, and most have been delivered.

L.1049H A Super-G modified for cargo work, the L.1049H is in demand (39 sold) as a convertible passenger-freighter.

L.1649A In this version the latest and most powerful Wright Turbo-Compounds, the EA-2s of 3,400 h.p., are matched with a completely new 150ft-span straight-taper wing—embodying integrally stiffened skin from tip to tip—which (with the exception of the Armagnac) is the biggest in airline service today. The L.1649A is a re-engineered Super Constellation in several important respects, particularly in systems. A full description appeared in *Flight*, July 6, 1956. Essentially a very long-range airliner, fuel tankage is 9,610 U.S. gal, with an ultimate range approaching 7,000 statute miles. Maximum seating capacity is 99. A total of 43 L.1649As have been ordered by four airlines: T.W.A. 29; Air France 10; Lufthansa, 4; at mid-October about 30 had been delivered. Cruising speed at 22,000ft in standard conditions and cruising power is 350 m.p.h.

Nord 2501 Noratlas Designed as a military transport, the Noratlas is also offered as a civil aircraft for mixed cargo/passenger work. Powerplant is two Hercules (SNECMA-licence), of 2,040 h.p.; gross weight 48,400 lb; typical cruising speed, 201 m.p.h.; disposal load (cargo version), 18,610 lb. A version with wing-tip Turbomeca Marboré jets, the 2502, is in service with the private French airline U.A.T.

Scottish Aviation Prestwick Twin Pioneer The world's first truly STOL transport aircraft, the Twin Pioneer, has now established itself in airline service. So far 25 have been sold to eight operators and plans for the production of 200 aircraft are now in hand. The Twin Pioneer has been described in *Flight* of March 18, 1955; July 15, 1955; September 30, 1955; and July 6, 1956. The aircraft is aimed at operators with limited airport facilities, serving outlying communities, and its application to inter-city services in competiton with helicopters is also evident. Powerplant is two Alvis Leonides 502 of 540/550 h.p. each; gross weight, 13,500 lb; capacity payload, 2,900 lb; max. payload, 3,500 lb; take-off field length, 894ft; typical cruising speed, 117 m.p.h.; fuel capacity, 180 Imp. gal; approximate basic price, £51,000.